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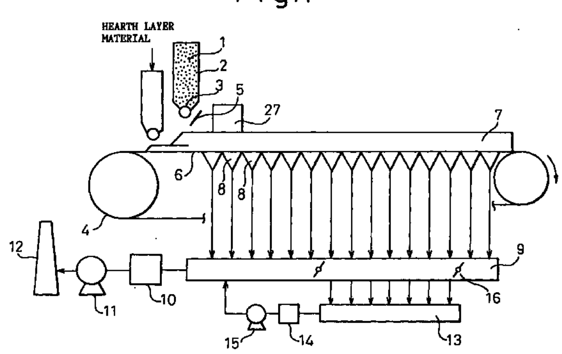
(54) METHOD OF MANUFACTURING SINTERED ORE AND SINTERING MACHINE THEREFOR

(57) The present invention provides a method of producing sintered ore and a sintering machine to which the method is applied, the product yield and the quality of which are high, and the method of producing sintered ore comprises the steps of: charging blended raw material containing fine ore, flux and fuel onto pallets of a sintering machine so as to form a raw mixture bed on the pallets; and igniting a surface layer of the raw mixture bed so as to conduct a sintering reaction on the raw mixture bed from an upper portion to a lower portion, wherein when the upper layer of the raw material has been sufficiently sintered, a mass flow rate of gas containing oxygen supplied onto the raw mixture bed layer is changed to a value 1.01 to 2.6 times as high as that of gas containing oxygen supplied in the case of sintering the upper layer of the raw material. It is preferable that when an end of the combustion and melting zone has reached a position lower than the position located at 20% of the height of the raw mixture bed from the surface layer, a mass flow rate of gas containing oxygen supplied onto the raw material layer is changed to a value described above.

Fig.1



EP 0 861 908 A1

Description

TECHNICAL FIELD

The present invention relates to a method of producing sintered ore, which is a raw material used for making pig iron by a blast furnace, and a sintering machine to which the method of producing sintered ore is applied. More particularly, the present invention relates to a method of producing sintered ore and a sintering machine therefor, in which a combustion and melting zone on a layer to be sintered is moved from an upper portion to a lower portion on pallets, and after a sintered layer of a predetermined thickness has been obtained, a volume of gas containing oxygen is increased, so that a pressure drop is increased and a sintering speed of the combustion and melting zone is extremely increased so as to enhance the productivity, quality and product yield of sintered ore.

BACKGROUND ART

When iron ore is sintered, the Dwight Lloyd type sintering machine is commonly used. Sintering operation is conducted by the Dwight Lloyd type sintering machine as follows. In preparation for blended raw material to be process by the sintering machine, fluxes such as limestone and quartz, fuel such as coke breeze, and water are added to fine iron ore and mixed with each other and granulated. The above blended raw material is charged onto sintering pallets which are arranged like a caterpillar. In this way, a raw mixture bed is formed on the pallets. The sintering pallets are successively moved in the horizontal direction, and a surface of the raw mixture bed is ignited in an ignition furnace. After that, air is sucked from a lower portion of the sintering machine, and fuel such as coke breeze contained in the blended raw material is burned. Therefore, fine iron ore is melted by the thus generated heat and then solidified. The burning zone is gradually shifted from the surface layer to the lower layer, and the charged iron ore is sintered. The sintering time is approximately 20 to 40 minutes.

Compared with a batch type sintering machine such as a Greeenawalt type sintering machine, the above Dwight Lloyd sintering machine is of a continuous type. Therefore, the above Dwight Lloyd sintering machine is suitable for mass production. That is the reason why the above Dwight Lloyd sintering machine is commonly used. The size of the presently used Dwight Lloyd sintering machine is increased, for example, there is provided a Dwight Lloyd sintering machine, the width of which is 5 m and the length of which is 100 m. The productivity of the Dwight Lloyd sintering machine is approximately 34 to 43 $t/d/m^2$.

In view of the worldwide circumstances with respect to natural resources, it is remarkable that lump iron ore used for producing iron by a blast furnace process cannot be sufficiently supplied. In accordance with the shortage of supply of lump iron ore, the price of lump iron ore goes on increasing. In order to solve the above problems, it becomes necessary to use a large quantity of fine iron ore. However, in order to increase production of sintered ore, it is necessary to install more sintering machines, or alternatively it is necessary to enhance the capacity of sintering machines. Therefore, a large amount of equipment investment is required, and further a volume of exhaust gas discharged from the sintering machine is increased, which causes environmental problems. For the above reasons, there is now an increasing demand for enhancing productivity of the sintering machine. In this case, when sintered ore is produced, it is required that the quality of produced sintered ore is sufficiently high so as to meet the requirement of making pig iron by a blast furnace, and that the productivity of producing sintered ore is made maximum. Further, it is required that the consumption units of fuel and the igniting fuel are minimized, and furthermore it is required to operate a sintering machine in such a manner that a volume of NOx discharged from the sintering machine is minimized as small as possible. Accordingly, when an actual operation is conducted in a sintering machine, as long as the quality of sintered ore can be maintained at a predetermined level, it is preferable to reduce quantities of flux such as quartz, serpentine and lime stone, quantities of fuel such as coke breeze and anthracite and quantities of igniting fuel such as coke oven gas and pulverized coal.

However, only when ratios of blending flux and fuel with raw material to be sintered are decreased, or only when a quantity of igniting fuel is decreased, it is impossible to obtain a good effect. On the contrary, when they are decreased greatly, the cold mechanical strength of sintered ore and RDI (reduction degradation index) are deteriorated, and further a quantity of returned ore is increased. In this case, unit requirements of fuel and igniting fuel are deteriorated, and further a ratio of conversion to NOx is deteriorated, and a quantity of NOx discharged from the sintering machine is increased. It is well known that RDI is greatly deteriorated when a quantity of SiO_2 contained in sintered iron ore is decreased by a ratio not higher than 5.0 mass%.

Japanese Examined Patent Publication (Kokoku) No. 55-19299 discloses the following technique. "There is provided a first half hood section of negative pressure in the first half of the upper portion of the strand. There is also provided a second half hood section of positive pressure in the second half of the upper portion of the strand. When exhaust gas in the second half hood section is circulated by the positive pressure in the second half section and the negative pressure in the first half section, it is possible to decrease a volume of exhaust gas and also it is possible to decrease the electric power rate and further it is possible to prevent the deterioration of productivity." However, according to the above method, the second half section, in which sintering is conducted by the atmosphere, is covered with the hood for positive pressure, and a blower successively connected to a wind box in the second half section is removed so as to decrease the equipment cost as small as possible. It is an object of this apparatus that the equipment cost is decreased as small as possible when a volume of exhaust gas is decreased by the exhaust gas circulating apparatus described above. In the above patent, there are no description of enhancing the productivity by positively increasing a shifting speed of the combustion and melting zone on the raw mixture bed. From the composition of exhaust gas, the exhaust gas characteristic and the drawings, which are disclosed in the above patent publication, it can be presumed that the completion of sintering in this method is in the beginning of the second half hood section, and cooling is conducted on the strand in the residual range of the second half hood section. This method is not a method in which the firing completion point is made to approach as close as possible to the ore discharging section so that the entire strand can be utilized to enhance the productivity to the maximum.

Japanese Examined Patent Publication (Kokoku) No. 56-19556 discloses the following technique. "There is provided a positive pressure hood to form a positive pressure sintering zone. At the end portion of the positive pressure hood on the ore feed and discharge sides, there is also provided a negative pressure hood to form a negative pressure zone. Due to the above arrangement, the productivity can be enhanced and the operation cost can be lowered by the pressurized sintering method without providing a pressure-tight housing to cover the entire apparatus." However, an object of this method is to prevent pressurized air from leaking into the atmosphere from the start end portion to supply raw material into the housing and also to prevent compressed air from leaking into the atmosphere from the conveying end portion to convey out sintered ore from the housing, wherein leakage of air from the above end portions are problems of the compressed sintering method of the conventional method. In the above patent publication, there are no description of enhancing the productivity by positively increasing a sintering speed on the raw mixture bed. In order to form a negative pressure zone by the suction in the end portion on the ore supply side, it is necessary to increase a flow velocity of suction in this portion more than the flow velocity of suction in the method of sucking the atmosphere of the conventional method. Due to the foregoing, a conventional problem of lack of high temperature holding time, in which an upper surface layer of the raw mixture bed is held at a high temperature, is occurred. Accordingly, the yield and quality of the upper surface layer of the raw mixture are deteriorated. As a result, the productivity cannot be enhanced by the above method in total.

Japanese Unexamined Patent Publication (Kokai) No. 61-243131 discloses the following technique. "In order to eliminate a large pressure-tight housing necessary for the compressed sintering method, there is provided a hood on the upper surface of sintered ore on the endless pallets, and air is forcibly fed into the hood so that the pressure in a wind box under the endless pallets is made negative. In this way, the cost can be decreased." However, an object of the above patent publication is to decrease a total electric power of the forced fan and the ventilating fan, and no explanations are made for enhancing the productivity by increasing a moving speed of the combustion and melting zone on the raw mixture bed. According to the sintering machine of the conventional method, in order to maintain a pressure drop between the upper portion and the lower portion of the raw mixture bed, which is an air pressure necessary for the sintering process, to be constant, the pressure of the forced draft fan and that of the ventilating fan are balanced with each other, and air at high temperature, the volume of which is expanded, is entirely exhausted. On the other hand, according to the above patent publication, air at the room temperature is supplied into the apparatus, so that the total electric power can be decreased. According to the patent publication described before, the sintering speed of the combustion and melting zone on the raw mixture bed is not positively increased for the purpose of enhancing the productivity.

Japanese Examined Patent Publication (Kokoku) No. 5-55574 discloses the following technique. "There are provided a plurality of divided wind boxes arranged in the longitudinal direction of the pallets. For each wind box divided in this way, in accordance with the sintering reaction of materials to be sintered which are charged and packed on the pallets, negative pressure for suction is decreased in the beginning of sintering reaction as compared with the negative pressure in normal operation, and is increased in the middle of the sintering reaction, and again is decreased in the final near to the end of sintering reaction. Due to the above control, it is possible to enhance the product yield on the upper layer of the sintering bed, the shatter Index (SI) and RDI. In addition to that, it is possible to decrease electric power necessary for exhaust, and further to effectively recover sensible heat in sintered ore." However, concerning the sintered ore on the upper layer of the sintering bed, RDI and SI have already been improved as compared with the sintered ore on the lower layer. Therefore, in order to improve the quality of the entire sintered ore, it is more important to improve the quality of sintered ore on the intermediate and the lower layer on the sintering bed. Although the product yield on the upper layer of the sintering bed, the quality of sintered ore and the consumption unit of electric power can be somewhat improved, the above patent aims at improvement in the balance of flow rates at the beginning, the middle and the end of sintering so that energy can be saved. Accordingly, the above patent is disadvantageous in that the product yield on the intermediate layer is deteriorated and SI of sintered ore on the lower layer is decreased.

In order to increase a quantity of energy recovered from sensible heat of sintered ore, it is necessary to raise the temperature of sintered ore at the end of the sintering process. Accordingly, it becomes necessary to increase a width of the red heat zone (combustion and melting zone) on the raw material packed layer in the direction of height of the combustion and melting zone. Due to the foregoing, ventilation resistance of the combustion and melting zone is greatly increased. Therefore, it becomes impossible to enhance the moving speed of the combustion and melting zone upon which the productivity depends greatly. For the above reasons, the productivity at the end of sintering process is deteriorated on the contrary. As a result, it is impossible to greatly enhance the total productivity of sintering.

Further, according to the above patent publication, in order to ensure the productivity in the middle stage of sintering reaction, negative pressure of suction is increased. However, as shown in the explanatory view disclosed in the above patent publication, although the negative pressure is increased in the intermediate stage as compared with that of the method of the conventional method, a volume of exhaust gas is decreased in a portion of the intermediate stage close to the beginning stage of sintering. Therefore, it can be considered that the total productivity cannot be greatly enhanced by the technique disclosed in the above patent publication.

DISCLOSURE OF INVENTION

The above techniques of the conventional method aim at improving costs of equipment and operation. Therefore, all techniques of the conventional method are based on the operating conditions in which blended raw material is charged onto the sintering pallets by the thickness of 400 to 600 mm, and fuel contained in the blended raw material is ignited in the ignition furnace.

Productivity of the sintering machine greatly depends upon the moving speed at which the combustion and melting zone on the raw mixture bed is gradually moved from the surface layer to the lower layer. In order to improve the productivity of sintering, there is caused a problem when the moving speed of the combustion and melting zone is low in the process of firing the raw material from the upper layer to the lower layer in the strand and from the igniting section to the sintered ore discharging section of the sintering machine. Accordingly, as long as the moving speed of the combustion and melting zone is the same as that of the conventional method, when the thickness of the raw mixture layer is increased or the moving speed of the sintering pallets is increased, the sintering machine length and the sintering time must be increased to complete sintering. Therefore, the productivity cannot be enhanced.

When the moving speed is increased too high, it becomes impossible to burn coke completely. As a result, it is impossible to obtain a quantity of heat necessary for sintering the raw material, which deteriorates the product yield and quality of sintered ore. Consequently, in order to greatly enhance the productivity of the sintering machine, it is important to ensure a quantity of heat necessary for sintering reaction, and also it is important to increase the moving speed of the combustion and melting zone. Sine the gas permeability resistance of the combustion and melting zone is high on the raw mixture bed, when the thickness of the raw mixture bed on the combustion and melting zone is minimized, it is possible to enhance the gas permeability and the burning speed of coke so as to increase the moving speed of the combustion and melting zone. As described above, controlling the cooling speed of the cooling zone located on the combustion and melting zone and the moving speed of the combustion and melting zone in a well balanced condition is important for greatly enhancing the productivity of the sintering machine.

In general, in order to increase the moving speed of the combustion and melting zone, it can be considered that the negative pressure of a blower is increased so as to increase the flow velocity of sucked gas, and that a volume of oxygen supplied to the raw mixture bed is increased.

However, in order to prevent the deterioration of the product yield of sintered ore on the upper layer of the raw mixture bed and also in order to prevent the deterioration of the quality of sintered ore, it is necessary to keep a temperature of the upper layer of the raw material to be high. For the above reasons, it is impossible to increase the moving speed of the combustion and melting zone in the sintering area on the upper layer of the raw material, that is, it is impossible to increase the moving speed of the combustion and melting zone in the front stage of the sintering strand. Further, the following problems may be encountered. When the negative pressure of the blower is increased, the raw mixture bed is compressed by the action of both gravity and blast pressure. Therefore, gas permeability of the raw material is deteriorated. Further, volumes of exhaust gas and leakage gas are increased. For the above reasons, the negative pressure of the exhaust gas is not increased too high.

On the other hand, for the purpose of decreasing a quantity of slag in the operation of a blast furnace into which highly pulverized coal is blown, there is a demand for producing sintered ore, in which content of SiO_2 is low. However, at that time of using the sintered ore, the productivity and RDI are deteriorated and a volume of NOx exhausted from the apparatus is increased. The above problems have not been solved yet.

The objects of the present invention are to provide a method of producing sintered ore by which the productivity of a sintering machine can be greatly enhanced when the thickness of the raw mixture bed and the moving speed of sintering pallets are increased, to provide a method of producing sintered ore having low SiO_2, and to provide a sintering machine to which the above methods can be applied.

The summary of the present invention to accomplish the above objects will be described as follows.

(1) A method of producing sintered ore, the product yield and the product quality of which are high, comprising the

steps of: charging blended raw material containing fine ore, flux and fuel onto pallets of a sintering machine so as to form a raw mixture bed on the pallets; and subsequently igniting a surface layer of the raw mixture bed so as to cause a sintering reaction on the raw mixture bed in the direction from an upper portion to a lower portion, wherein when the upper layer of the raw material has been sufficiently sintered, a mass flow rate of gas containing oxygen supplied onto the raw mixture bed is changed to a value 1.01 to 2.6 times as high as that of gas containing oxygen supplied in the sintering of the upper layer of the raw material.

(2) A method of continuously producing sintered ore, the product yield and the product quality of which are high, comprising the steps of: charging blended raw material containing powder ore, flux and fuel onto pallets of a sintering machine so as to form a raw mixture bed on the pallets; and subsequently igniting a surface layer of the raw mixture bed while a combustion and melting zone is being moved from an upper portion to a lower portion, wherein when an end of a forming range of the combustion and melting zone has reached a position lower than a position located at 20% of the height of the raw mixture bed from the surface layer, a mass flow rate of gas containing oxygen supplied onto the raw mixture bed is changed to a value 1.01 to 2.6 times as high as that of gas containing oxygen supplied in the sintering of the raw mixture bed before reaching the position.

(3) A method of producing sintered ore according to the item (1) or (2), further comprising the steps of: arranging a pressure hood for giving pressure to gas containing oxygen on the raw mixture bed on the sintering pallets; giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure; and sucking gas from a lower portion of the raw mixture bed by the negative pressure of -2000 to -1 mmAq with respect to the atmospheric pressure.

(4) A method of producing sintered ore according to any one of the items (1) to (3), further comprising the steps of: arranging a pressure hood for giving pressure to gas containing oxygen in a range from 5 to 95% in the pallet width direction on the raw mixture bed on the sintering pallets; and giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure.

(5) A method of producing sintered ore according to the item (3) or (4) further comprising the steps of: arranging a pressure hood for giving pressure to gas containing oxygen on the raw material layer in a range after an end of a forming range of the combustion and melting zone has reached a position located at 20% of the height of the raw mixture bed from the surface layer; and giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure.

(6) A method of producing sintered ore according to any one of the items (3) to (5), wherein sintering exhaust gas is circulated in the pressure hood for giving pressure to gas containing oxygen arranged on the raw mixture bed.

(7) A method of producing sintered ore according to any one of the items (1) to (6), wherein sintering is conducted iron ore by a Dwight Lloyd type sintering machine in which a plurality of plate-shaped sintered ore supporting stands are arranged on the grates of the sintering pallets substantially in parallel with the pallet advancing direction.

(8) A method of producing sintered ore according to any one of the items (1) to (7), wherein sintered ore containing SiO_2 of 3.9 to 4.9 mass% in chemical composition is produced by the method.

(9) A method of producing sintered ore according to any one of the items (1) to (8), wherein layer thickness of the raw mixture bed is 600 to 1500 mm.

(10) A sintering machine of the down-suction type comprising: a plurality of wind boxes arranged in a lower portion of the sintering strand, the wind boxes being connected with a suction duct in parallel with each other; a main blower arranged in the suction duct; and another blower for sucking gas from the duct in a range from 30% of the length of the suction duct from the igniting section to the sintercake discharging section, to the sintering completion point, and for discharging gas into the suction duct.

(11) A sintering machine comprising: a plurality of wind boxes arranged in a lower portion of the sintering strand, the wind boxes being connected with a suction duct in parallel with each other, wherein the suction duct is divided into a range from 30% of the length of the strand from the igniting section to the sintercake discharging section, to the sintering completion point, and into a residual range; and blowers independently arranged in the ranges.

(12) A sintering machine according to the item (10) or (11), further comprising a pressure hood for feeding and compressed gas containing oxygen, arranged on the raw mixture bed on the sintering pallets.

(13) A sintering machine according to the item (10) or (11), further comprising a pressure hood for supplying and compressed gas containing oxygen, arranged on the mixture bed layer in a range in which an end of a forming range of the combustion and melting zone has reached a position located lower than the surface layer of the raw mixture bed by a distance of 20% of the height of the raw mixture bed.

(14) A sintering machine according to the item (12) or (13), further comprising a pressure hood for supplying and compressed gas containing oxygen, arranged on the raw mixture bed on the sintering pallets in a range of 5 to 95% in the pallet width direction.

(15) A sintering machine according to any one of the items (12) to (14), wherein sintering exhaust gas is circulated in the pressure hood for supplying and compressed oxygen arranged on the raw mixture bed.

(16) A sintering machine according to any one of the items (12) to (15), wherein a sealing mechanism is arranged

in a lower end portion of the pressure hood for supplying and compressed gas containing oxygen.

(17) A sintering machine of the down-suction type according to any one of the items (10) to (16), further comprising a plurality of plate-shaped sintered ore supporting stands arranged on the grates of the sintering pallets substantially in parallel with the pallet advancing direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration showing an embodiment of the sintering machine according to the examples 1a and 3a of the present invention.

Fig. 2 is a schematic illustration showing an embodiment of the sintering machine according to the example 1b of the present invention.

Fig. 3 is a schematic illustration showing an embodiment of the sintering machine according to the examples 1c to 1e and 3b of the present invention.

Fig. 4 is a schematic illustration showing an embodiment of the sintering machine according to the examples 2a to 2d and 3c of the present invention.

Fig. 5 is a schematic illustration showing another embodiment of the sintering machine of the present invention.

Fig. 6 is a cross-sectional view showing the sealing mechanism of the pressure hood of the sintering machine of the present invention.

Fig. 7 is a perspective view showing sintered ore supporting stands of the sintering machine of the present invention.

Fig. 8(a) is a schematic illustration showing a transition of the combustion and melting zone on the pallets in the present invention, Fig. 8(b) is a cross-sectional view of the combustion and melting zone taken on line A - A' in Fig. 8(a) of the present invention, and Fig. 8(c) is a schematic illustration showing a transition of the combustion and melting zone on the strand in the case of cooling in the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

In general, sintered ore is produced in such a manner that blended raw material containing fine iron ore, flux and fuel is charged onto pallets of the Dwight Lloyd type sintering machine so that a raw mixture bed can be formed on the pallets, and it is ignited in the igniting section, and then the raw mixture bed is moved to the sintercake discharging section of the sintering machine while gas containing oxygen is being sucked downward through the raw mixture bed from a lower portion. Accordingly, sintering is conducted on the raw mixture bed in the direction from an upper portion to a lower portion of the raw mixture bed. However, since sintering can be conducted in accordance with the direction of the strand length, and in order to clarify understanding, the present invention will be explained using the strand length, hereinafter.

Fig. 8(a) is a schematic illustration showing an example of a transition of the combustion and melting zone on the pallets in the present invention. In this schematic illustration, reference numeral I is an initial raw material zone, reference numeral II is a wet zone (water condensing zone), reference numeral III is a drying zone, reference numeral IV is a combustion zone, reference numeral V is a melting zone, and reference numeral VI is a sintering zone. Fig. 8(b) is a cross-sectional view of the central portion taken on line A - A' in Fig. 8(a). In this schematic illustration, point B represents a position closest to the ignition furnace at which the combustion and melting zone is formed in the initial stage in the present invention and a volume of gas containing oxygen to be supplied onto the raw mixture bed is changed so that it can be increased, and point C represents a combustion completion point. In order to stably produce sintered ore using the entire strand effectively, operation is usually conducted so that the sintering completion point can be located at a constant position. When they take a serious view of the production of sintered ore, operation is conducted in such a manner that the sintering completion point is made to come near to the sintercake discharging side as closely as possible. When they take a serious view of the product yield and quality of sintered ore, the sintering completion point is made to be a constant position so that it comes near onto the ignition furnace side while a distant space corresponding to one or two times of wind box length is left. However, cooling is conducted on the raw mixture bed on the strand, for example, as shown in Fig. 8(c), operation is conducted in such a manner that the sintering completion point C' is changed to an intermediate portion of the strand. In this case, a volume of gas containing oxygen supplied to the raw mixture bed may be changed at the layer thickness or the position in the strand length direction in accordance with the present invention disclosed below. In the following explanations, the sintering completion point is located at a position distant from the igniting section by the distance of 95% of the strand length. In this connection, the air blasting pressure and the suction pressure are shown by the pressure with respect to the atmospheric pressure.

A range in the distance not more than 30% of the strand length from the igniting section approximately corresponds to a sintering area of 20% of the upper layer. In general, the product yield and quality of the upper layer of the raw material is inferior to that of the intermediate and the lower layer. The reason is because the coke burning speed on the upper layer, by which a quantity of heat necessary for the sintering reaction is given, is not sufficiently high immediately after the ignition, and further heat is emitted from the surface of the upper layer. Accordingly, it is necessary to ensure a quantity of heat required for the sintering reaction on the upper layer. For the above reasons, it is not preferable that the moving speed of the combustion and melting zone is increased in the sintering process of the upper layer of the raw material, because the product yield and quality of sintered ore is deteriorated.

Therefore, according to the present invention, when a range from the igniting section to a position distant from the igniting section by not more than 30% of the strand length, this range is a sintering area of the upper layer of the raw material, is kept in a negative pressure of suction in the same manner as that of the conventional method, it becomes possible to ensure a period of time in which the upper layer of the raw material is held at a high temperature. Therefore, the product yield and quality of the upper layer of the raw material can be maintained high.

In order to positively enhance the product yield and quality of the upper layer of the raw mixture bed, a quantity of heat generated by sintering may be increased in this upper layer. In order to increase a quantity of heat generated by sintering in this upper layer, it is preferable that the negative pressure of suction is lowered in this section, the coke segregation is occurred in the upper portion of the raw mixture bed, and coke breeze is made to flow onto the surface layer. Alternatively, it is possible to give heat from the outside of the raw mixture bed, for example, a hot blast is supplied to this portion, or alternatively induction heating of microwaves may be conducted.

A range from the igniting section to a position distant from the igniting section by 30 to 95% of the strand length corresponds to a sintering area of the intermediate and the lower layer of the raw material. The gas permeability resistance in the sintering zone on the upper layer is low. On the other hand, thickness of the combustion and melting zone of the intermediate layer and that of the lower layer are large, so that the gas permeability resistance is high thereon. Especially in a range from the igniting section to the position distant from the igniting section by 50 to 95% of the strand length, the gas permeability is deteriorated and a quantity of heat generated by sintering is increased too large. When operation is conducted as follows, a quantity of heat necessary for sintering can be ensured, and thickness of the combustion and melting zone can be decreased so that the gas permeability property can be enhanced. Gas containing oxygen is forcibly supplied from the upper portion to the combustion and melting zone, the pressure loss of which is large, in the range (the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length) on the intermediate and the lower layer. A mass flow rate of gas containing oxygen is increased 1.01 to 2.6 times as high as that of gas containing oxygen supplied to the raw mixture bed in the range of the strand except for the aforementioned range. Due to the foregoing, the coke burning speeds on the intermediate and the lower layer are increased, so that the moving speed of the combustion and melting zone is increased, and further the cooling speed of the cooling zone above the combustion and melting zone is increased. In this way, the gas permeability can be enhanced while a quantity of heat necessary for sintering is ensured and thickness of the combustion and melting zone is decreased. As described above, in order to enhance the productivity of sintering, it is important to control temperature in the combustion and melting zone, and a quantity of heat for sintering which depends upon the thickness of the raw mixture bed in the height direction. Also, it is important to control gas permeability.

In the present invention, a mass flow rate represents a mass of gas flowing per unit time. The unit of mass flow rate is expressed by kg/s. A rate of flow commonly used represents a volumetric flow rate. This volumetric flow rate represents a volume of gas flowing per unit time. The unit of the volumetric flow rate is expressed by m^3/s. When the mass flow rate is the same, the volumetric flow rate is changed by temperature and pressure in accordance with the equation of state in gas.

Gas containing oxygen described in the present invention includes the atmosphere, exhaust gas discharged from a sintering machine, exhaust gas discharged from other processes, mixed gas in which the atmosphere is mixed with exhaust gas, and gas enriched with oxygen gas. It is preferable that the oxygen concentration in gas is 12 to 40 vol%.

In this case, the reason why a mass flow rate of gas containing oxygen supplied to the charged raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is adjusted to be 1.01 to 2.6 times as high as the mass flow rate of gas containing oxygen supplied to the raw mixture bed in the ranges except for the aforementioned range, is described as follows. When the mass flow rate of gas containing oxygen is lower than 1.01 times, the moving speed of the combustion and melting zone is seldom changed. When the mass flow rate of gas containing oxygen is higher than 2.6 times, the flow velocity of gas is increased too high, and the combustion and melting zone is undercooled. Further, a pressure drop between the upper and the lower layer of the raw material is increased, so that the raw mixture bed is compressed with pressure. As a result, the gas permeability is deteriorated. Further, from the viewpoint of enhancing the productivity of sintered ore, it is especially preferable that the mass flow rate of gas containing oxygen supplied to the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 50 to 85% of the strand length is adjusted to be 1.1 to 1.8 times as high as the mass flow rate of gas containing oxygen fed to the raw mixture bed in the range except for the aforementioned range.

In the case where the atmosphere is used as gas containing oxygen and sucked to increase the moving speed of the combustion and melting zone, in order to make the mass flow rate to be the predetermined value, it is preferable that a pressure drop in the direction of the thickness of the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is made to be 1.1 to 5.0 times as high as that in the direction of the thickness of the raw mixture bed in the strand range except for the aforementioned range. In this case, the gas permeability resistance in the range of 30 to 95% of the strand length is 1.5 to 5 times higher than that of other ranges. Accordingly, when the pressure drop is smaller than 1.1 times, the moving speed of the combustion and melting zone is not sufficiently attained by an increase in the gas volume. When the pressure drop exceeds 5.0 times, the flow velocity of gas is increased too high, and the cooling speed is greatly increased. Therefore, it becomes difficult to ensure a period of time in which the raw mixture bed is kept at high temperature, and the raw mixture bed is compressed and the density is increased, and the gas permeability is deteriorated. For the above reasons, it is not preferable that the pressure drop is smaller than 1.1 time and the pressure drop exceeds 5.0 times. From the viewpoint of enhancing the productivity, it is most preferable that the pressure drop is kept at 1.2 to 2.0 times. In this connection, it is preferable that a volume of gas to be supplied is gradually increased when it comes from the igniting section side to the sintercake discharging side so that the moving speed of the combustion and melting zone and the cooling speed can come close to each other. The reason why the volume of gas to be supplied is gradually increased is described as follows. When the volume of gas to be supplied is suddenly increased, the cooling speed is increased higher than the burning speed of coke although its period of time is short. Therefore, it becomes impossible to keep a sufficiently large quantity of heat for sintering in some portions. As a result, the product yield and quality of sintered ore in these portions are deteriorated.

As described above, when the pressure drop on the raw mixture bed in the range from the igniting section to a position distant from the igniting section by 30 to 95% of the strand length is increased so that the mass flow rate of gas can be increased, it is possible to greatly enhance the productivity of sintered ore, and it is also possible to provide products of high product yield and quality. When the pressure drop is increase so as to increase the volume of gas to be supplied, a volume of exhaust gas is also increased in this portion. However, since the sintering reaction is active and the oxygen consumption efficiency is high in this portion, a volume of surplus gas supplied to the upper layer and the sintercake discharging section can be decreased as small as possible without deteriorating the oxygen consumption efficiency. For the above reasons, it is possible to decrease a unit requirement of gas volume.

The present inventors found the following. When gas is sucked from a lower portion of the raw mixture bed and at the same time gas is supplied with pressure from an upper portion of the raw mixture bed so that a mass flow rate of gas containing oxygen can be increased, it is possible to avoid a deterioration of gas permeability caused by a compressed raw mixture bed, and a mass flow rate of gas containing oxygen supplied to the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is adjusted to be 1.01 to 2.6 times as high as the mass flow rate of gas containing oxygen supplied to the raw mixture bed in the ranges except for the aforementioned range, and a pressure drop in the direction of the thickness of the raw mixture bed is adjusted to be 1.1 to 5.0 times as high as that in the direction of the thickness of the raw mixture bed in the strand range except for the aforementioned range. Due to the foregoing, it is possible to increase the moving speed of the combustion and melting zone, and the yield and quality of products can be enhanced.

There is provided a pressure hood covering the raw mixture bed that has been charged onto the sintering pallets. The pressure hood is compressed, and gas containing oxygen is supplied from an upper portion onto the raw mixture bed, and at the same time gas is sucked and exhausted from a wind box arranged immediately below the pallets. While a pressure drop between the upper portion and the lower portion of the raw mixture bed is controlled in this way, gas is made to flow from the upper portion to the lower portion of the raw mixture bed. According to the method of the prior art, the atmospheric pressure is kept on the raw mixture bed, and gas is sucked from a lower portion of the raw mixture bed so as to maintain a static pressure on the raw mixture bed. On the other hand, according to the method of the present invention, a static pressure on the raw mixture bed can be increased by the way described above. When the pressure drop between the upper portion and the lower portion of the raw mixture bed of the method of the present invention is the same as that of the method of the conventional method in which the atmosphere is sucked, it is possible to increase a mass flow rate of gas supplied to the raw mixture bed by the present invention as compared with the method of the conventional method, and further the density of gas in the raw mixture bed can be increased as compared with the method of the conventional method. As a result, a volume of gas containing oxygen supplied into the raw mixture bed is increased, and the burning speed of coke on the raw mixture bed can be increased. Therefore, it becomes possible to increase a quantity of heat of sintering in the combustion and melting zone. Further, the moving speed of the combustion and melting zone can be increased, and furthermore the moving speed of the cooling zone can be increased. When the static pressure in the raw mixture bed is increased, a rate of heat transfer between gas and solid is also increased. Accordingly, the combustion and melting zone can be positively moved, and the cooling zone can be effectively cooled.

In the case of a forced gas permeability conducted from an upper portion of the raw mixture bed, gas can be supplied to the combustion and melting zone, in which a reaction is caused, through the sintered zone, the resistance of gas permeability of which is low, forming a uniform gas flow. On the other hand, in the case of supplying gas by sucking from a lower portion of the raw mixture bed, resistance of gas permeability is given by the wet zone, the resistance of gas permeability of which is relatively high, and also resistance of gas permeability is given by the combustion and melting zone in which the sintering reaction is caused. Due to the resistance of gas permeability described above, gas flows preferentially in a portion, in which the resistance of gas permeability is low. Accordingly, an ununiformed gas flow is formed in the raw mixture bed, and the efficiency of reaction caused between gas and solid is deteriorated. As described above, the gas flow forcibly supplied from the upper portion can form a uniform gas flow compared with the gas flow of suction from the lower portion. Therefore, the oxygen consumption efficiency can be enhanced, and the unit requirement of gas volume necessary for producing sintered ore can be decreased.

Further, when a pressure drop on the raw mixture bed in the range of 30 to 95% of the strand length is increased, the effect obtained by an increase in the mass flow rate of gas caused by an increase in the pressure drop is added to the effect obtained by an increase in the static pressure. Therefore, the effect of enhancing the productivity can be greatly enhanced.

In order to increase a mass flow rate of gas in the raw mixture bed and also in order to increase a static pressure in the raw mixture bed compared with the method of the conventional method, pressure in the pressure hood arranged in an upper portion of the raw mixture bed is increased to a value in the range from 100 to 3000 mm, and gas, the pressure of which is -2000 to -1 mmAq, is sucked from a lower portion of the raw mixture bed. When the pressure in the upper portion of the raw mixture bed is lower than 100 mmAq, the productivity cannot be enhanced so high as that in the operation of the conventional method. When the pressure in the upper portion of the raw mixture bed is higher than 3000 mmAq, a pressure drop between the upper and the lower portion of the raw mixture bed is excessively increased. Therefore, the raw mixture bed is too strongly compressed by both gravity and gas pressure. Accordingly, density of the raw mixture bed is increased too high, and gas permeability is deteriorated. When gas pressure is further increased, leakage of gas is increased between the hood and a member coming into contact with the hood, so that it becomes difficult to seal, and equipment cost is increased. Although depending upon the setting of a pattern in pressure drop between the upper and the lower portion of the raw mixture bed, a negative pressure of suction given to the wind box arranged immediately below the pallets is set in the range from -2000 to -1 mmAq. The reason why the negative pressure of suction given to the wind box is set as described above will be explained as follows. When the negative pressure is lower than -2000 mmAq, even if the upper portion of the raw mixture bed is compressed, the static pressure in the raw mixture bed is substantially the same as that of the method of the conventional method. Accordingly, a rate of heat transfer caused by the increase in the coke burning speed and the increase in gas density is low. When the negative pressure is higher than -1 mmAq, it becomes impossible to suck exhaust gas.

Although depending upon the layer thickness and the moving speed of pallets, it is preferable that a pressure drop between the upper and the lower portion of the raw mixture bed in the range from the igniting section to a position distant from the igniting section by 30 to 95% of the strand length is 1000 to 3000 mmAq. When the pressure drop between the upper and the lower portion of the raw mixture bed is smaller than 1000 mmAq, the pressure drop in the raw mixture bed is smaller than that of the method of the conventional method. Accordingly, a bad influence is exerted by the reduction of gas velocity rather than the effect obtained by increasing the static pressure. It is not preferable to increase the pressure drop in the raw mixture bed to a value exceeding 3000 mmAq, because the raw mixture bed is compressed by both gravity and gas blasting pressure. Accordingly, density of the raw mixture bed is increased too high, and gas permeability is deteriorated.

When there is provided a pressure hood, which is divided into a plurality of portions in the direction of strand length, in the overall range from the igniting section to the sintercake discharging section, the following advantages can be provided. A mass flow rate of gas containing oxygen sucked into the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is adjusted to be 1.01 to 2.6 times as high as the mass flow rate of gas containing oxygen supplied to the raw mixture bed in the ranges except for the aforementioned range, and a pressure drop in the direction of the thickness of the raw mixture bed is adjusted to be 1.1 to 5.0 times as high as that in the direction of the thickness of the raw mixture bed in the strand range except for the aforementioned range.

As described before, in the range from the igniting section to the position distant from the igniting section by 30% of the strand length, it is necessary to ensure a period of time for keeping iron ore at high temperature so that the product yield and quality of sintered ore can be prevented from deteriorating. Accordingly, when the upper layer of the raw material is sintered, it is impossible to increase the sintering speed of the combustion and melting zone to be higher than that of the present method. In the case of a conventional layer thickness from 400 to 600 mm, when operation is conducted as follows, it is possible to ensure or extend a period of time in which the raw mixture bed is kept at high temperature, and it is also possible to obtain a quantity of heat necessary for sintering. In the range from the igniting section to the position distant from the igniting section by 30% of the strand length, gas is supplied from an upper portion of the raw mixture bed by the pressure of 100 to 1000 mmAq, and the negative pressure of suction from the wind box arranged immediately below the pallets is set at -1000 to -1 mmAq. The pressure drop between the upper and the lower portion of the raw material layer is adjusted at 300 to 2000 mmAq, so that the pressure drop is made to be the same as or smaller than the pressure drop of the conventional suction conducted from a lower portion. In this way, the period of time for holding a high temperature can be ensured or extended, and a quantity of heat necessary for sintering can be obtained. Since the oxygen supplying rate onto the upper layer of the raw material is increased at this time, it is possible to obtain an effect of enhancing the burning property of coke in the same manner as that of enrichment with oxygen. Accordingly, it is possible to further enhance the product yield and quality of the upper layer in the raw material.

However, in the ranges of the raw mixture bed except for the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length, even if suction is conducted from a lower portion according to the conventional method, the obtained effect is relatively small. For the above reasons, from the viewpoint of simplifying the apparatus, it is preferable that the pressure hood is arranged in a range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length. Further, when pressure hood is divided into a plurality of portions in the longitudinal direction of the strand, it becomes possible to change stepwise a mass flow rate from the igniting section side to the sintercake discharging section side.

The resistance of gas permeability in a portion of the raw mixture bed close to the side wall of the pallets, which is distant from the side wall by a distance not larger than 5% in the width direction, is not higher than the resistance of gas permeability at the center of the raw mixture bed. Accordingly, the moving speed of the combustion and melting speed is high in this portion. Therefore, when the pressure hood is arranged in a range from 5 to 95% of the raw mixture bed in the width direction and gas is applied so that the moving speed of the combustion and melting zone can be made uniform in the width direction, the effect of increasing the moving speed of the combustion and melting zone can be further enhanced.

Although the pressure hood is arranged in an upper portion of the sintering pallets which are moving, in order to prevent the leakage of a blast of gas, it is preferable to arrange a sealing mechanism at a lower end of the pressure hood. As an example of the sealing mechanism is shown in Fig. 6, a sheet 24 is arranged at the lower end portion of the pressure hood 19. When the sheet 24 is pressed against an upper surface of the raw mixture bed 7 by the internal pressure of the pressure hood 19, sealing can be attained. When the pallets are moved, the sheet 24 slides on the upper surface of the raw mixture bed 7. It should be noted that the sealing mechanism is not limited to the above specific example. For example, several stages of sealing mechanisms may be arranged, or air is blown to between the pressure hood 19 and the raw mixture bed 7 from the outside of the pressure hood 19, or alternatively a sealing mechanism may be arranged by utilizing the side walls of the pallets 6.

When gas, the oxygen concentration of which has already been adjusted to a value in the range from 12 to 21 vol%, is applied into the pressure hood in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length, preferably into the pressure hood in the range from the igniting section to the position distant from the igniting section by 60 to 80% of the strand length, and when the raw mixture bed is sintered by the thus applied gas, the generation of magnetite effective for enhancing RDI can be enhanced, and the oxidation of nitrogen contained in coke into NOx can be suppressed. That is, it is effective for improving RDI and suppressing the generation of NOx. In order to adjust the concentration of oxygen in the pressure hood to a value in the range from 12 vol% to 21 vol%, it is possible to utilize a portion of exhaust gas of the sintering machine when the portion of exhaust gas is circulated. In this case, the capacity of a blower for circulating exhaust gas is designed by giving consideration to the negative pressure of suction, gas volume and size of the apparatus so that exhaust gas can be sent to an exhaust gas control device after it has been fed from an upper portion of the raw mixture bed.

When the concentration of oxygen is lower than 21 vol%, RDI can be improved because the generation of magnetite is enhanced, and further the oxidation of nitrogen contained in coke to NOx can be suppressed because the concentration of oxygen is low. However, when the concentration of oxygen is lower than 12 vol%, a bad influence caused by the reduction of productivity becomes remarkable. For the above reasons, it is preferable that the concentration of oxygen is maintained not lower than 12 vol% and lower than 21 vol%. Especially when the concentration of oxygen is lower than 18 vol%, RDI can be remarkably improved and the generation of NOx can be effectively suppressed.

As disclosed in Japanese Unexamined Patent Publication (Kokai) No. 4-168234, a sintering machine includes a plurality of plate-shaped sintered ore supporting stands arranged in parallel with the pallet advancing direction in the width direction, so that sintered ore can be supported by the plurality of plate-shaped sintered ore supporting stands. Due to the above arrangement, a load of sintered ore is not given to the lower layer of the raw material layer. Therefore, the gas permeability on the lower layer of the raw material can be improved. As a result, the productivity can be greatly improved. In accordance with the reduction of the load of sintered ore, it becomes possible to increase a pressure drop between an upper portion and a lower portion of the raw mixture bed. Therefore, the productivity can be further enhanced. An example of the sintered ore supporting stand is shown in Fig. 7. The most appropriate number of the plate-shaped sintered ore supporting stands 21 depends upon the size of the pallet 6. For example, in the case of a sintering machine, the width of the pallet of which is 4 m, the length of the pallet of which is 1.5 m, the thickness of the raw mixture bed of which is 500 to 600 mm, it is preferable that the number of the plate-shaped sintered ore supporting stands 21 is 2 to 10 and the height is 200 to 400 mm. The larger the number of the sintered ore supporting stands is, the higher effect can be provided for supporting sintered ore. However, when the number of the sintered ore supporting stands exceeds 10, a volume occupied by the sintered ore supporting stands is increased. Therefore, the productivity is deteriorated on the contrary. When sintered ore is supported by the sintered ore supporting stands, the gas permeability can be further enhanced, and the burning rate of coke is increased. Accordingly, the generation of CO is increased, and a chemical reaction to reduce NO by CO gas generated in the above process becomes active. In this way, the generation of NOx can be suppressed. As described above, when a plurality of sintered ore supporting stands are arranged according to the present invention, it is possible to realize the suppression of generation of NOx, the enhancement of productivity, the enhancement of production yield and the enhancement of quality of sintered ore, which are difficult to be compatible with each other by the method of the conventional method.

The present invention is effective especially when sintered ore containing SiO_2 by 3.9 to 4.9 mass% is produced. The reason is described as follows. When SiO_2 content is not higher than 4.9 mass%, a compounding ratio of lime stone is lowered, and the principal components of slag such as CaO and SiO_2 are decreased. Due to the foregoing, the productivity and RDI starts being deteriorated, and when SiO_2 content becomes lower than 3.9 mass%, it is impossible to improve the productivity and RDI even by the present invention.

According to the present invention, a mass flow rate of gas containing oxygen sucked to the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is adjusted to be only 2.6 times as high as the mass flow rate of gas containing oxygen sucked to the raw mixture bed in the ranges except for the aforementioned range. Therefore, in the sintering operation in which the thickness of the raw mixture bed is 400 to 600 mm which is the layer thickness of the conventional method, it is possible to increase the moving speed of the sintering pallets twice as high as that of the method of the conventional method. Further, it is even possible to increase the thickness of the raw mixture bed to 600 to 1500 mm which is more than twice as large as the thickness of the method of the conventional method. Due to the foregoing, it is possible to enhance the productivity of the sintering machine twice as high as the productivity of the sintering machine of the conventional method at the maximum. In this way, the productivity can be greatly enhanced, and the product yield and quality can be enhanced and further the unit requirement of exhaust gas volume can be reduced. It is also possible to enhance the product yield and quality and decrease the unit requirement of exhaust gas volume while the productivity is kept constant.

The lower the negative pressure of suction to be sucked from a lower portion of the raw mixture bed is, the smaller a volume of outside air flowing from a sliding section between the pallets and the wind box can be decreased. Accordingly, a volume of gas effectively used for sintering can be increased, and a volume of leakage of gas can be decreased. Therefore, the productivity can be further enhanced and the unit requirement of a volume of gas can be further decreased.

The sintering machine used for the method of producing sintered ore of the present invention is composed as follows. A plurality of wind boxes arranged in a lower portion of the sintering strand are connected with a suction duct in parallel with each other, and a main blower is arranged in the suction duct. In addition to the above arrangement of the conventional method, another blower is arranged for sucking gas from the duct in a range from the igniting section to a position distant from the igniting section by 30% of the length of the suction duct, and for discharging gas into the suction duct. Due to the above arrangement, a mass flow rate of gas containing oxygen sucked into the raw mixture bed in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length is adjusted to be 1.01 to 2.6 times as high as the mass flow rate of gas containing oxygen applied to the raw mixture bed in the ranges except for the aforementioned range, and a difference in pressure in the direction of the thickness of the raw mixture bed further can be adjusted to be 1.1 to 5.0 times as high as that in the direction of the thickness of the raw mixture bed in the strand range except for the aforementioned range.

Furthermore, from the viewpoint of adjusting a mass flow rate and a pressure drop, it is preferable that the suction duct is divided into a range located from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length and a residual range, and blowers are independently arranged in the respective divided regions. In this case, the blowers may be respectively arranged in the first stage, intermediate stage and latter stage. However, since it is unnecessary to make the pressure drop in the first stage to be different from the pressure drop in the latter stage, it is preferable that the first stage and the latter stage are connected with each other, and two blowers are arranged, wherein one blower is used for the intermediate stage in the range from the igniting section to the position distant from the igniting section by 30 to 95% of the strand length, and the other blower is used for the ranges except for the aforementioned range.

In the case of giving pressure from an upper portion, it is preferable that a hood is arranged above the raw mixture bed to be pressurized, so that pressure is given inside the hood, and pressure in the hood and pressure in the wind box located below the hood are measured. Further, it is preferable that a sealing mechanism is arranged between the hood and the raw material packed layer and/or between the hood and the pallets.

EXAMPLES

Referring to Examples 1, 2 and 3, the present invention will be explained in detail.

An actual sintering machine, the sintering area of which was 500 m^2, the sintering pallet width of which was 4 m, was partially changed so that it was used as a testing sintering machine, and operation tests were made for 7 days with respect to each level of the testing condition.

EXAMPLE 1

Figs. 1 to 3 are schematic illustrations showing an example of the sintering machine of the present invention. Blended sintering material 1 is continuously supplied from the surge hopper 2 onto the pallets 6 via the drum feeder 3 and raw material charging device 5. When blended sintering material 1 is fed onto the pallets 6, it is laminated on the pallets 6 as a raw mixture bed 7. While the blended sintering material 1 is being supplied, the sprocket 4 arranged on the raw material feeding side is rotated, so that the pallets 6 are moved at a predetermined speed, and at the same time, gas is sucked by the blower 11 via a plurality of wind boxes 8 arranged on the lower side of the pallets 6, main duct 9 and dust collector 10 for collecting dust from exhaust gas. Further, in a portion of the main duct 9, there is arranged a sub-duct 13 through which gas is sucked by the blower 15 via the dust collector 14 for collecting dust from exhaust gas. The thus sucked exhaust gas is returned to the main duct 9. It is possible to discharge exhaust gas, which has been sucked by the blower 15, from the stack 12. It is preferable to arrange dampers 16 in the main duct 9 to adjust negative pressure in the duct.

This sintering machine is continuously operated as follows. An upper surface of the raw mixture bed is ignited by the ignition furnace 27, and the moving speed of the pallets 6 is controlled so that the entire raw mixture bed 7 on the pallets 6 can be sintered until it reaches the sintercake discharging section. Exhaust gas can be circulated from a portion before the stack 12 into the pressure hood 19 by the blower 18, and at the same time air can be mixed with exhaust gas. In the case of giving pressure to the inside of the pressure hood 19, the sealing mechanism 23 is arranged between the surface layer of the raw material and the lower end portion of the pressure hood 19 as shown in Fig. 6. Internal pressure of the pressure hood 19 can be kept by the action of this sealing mechanism 23. It is possible to freely determine the length of the pallets in the pallet advancing direction, and also it is possible to freely determine the length of the pallets in the pallet width direction. In this sintering machine, it is possible to determine the thickness of the raw mixture bed 7 to be 600 to 1500 mm, which is larger than the thickness of the raw mixture bed in the sintering machine of the conventional method.

When blended raw material was prepared, the inventors did not particularly aim at producing sintered ore of low SiO_2, but they adopted a conventional common composition, that is, various iron ores, lime stone, quick lime, serpentine, scale, returned ore and coke breeze were adjusted so that SiO_2 content in sintered ore could be 5.8 mass%, Al_2O_3 content in sintered ore could be 1.8 mass% and the basicity of sintered ore could be 1.7. A ratio of returned iron ore to new raw material was determined to be 15% with respect to 100 of new raw material, and it was kept constant. A ratio of coke to new raw material was determined to be 4.2% with respect to 100 of new raw material, and it was kept constant. The composition of the comparative example and that of the inventive example were the same.

After returned iron ore and coke breeze had been mixed with blended raw material, water was added. Then the blended raw material was mixed by a mixer and granulated. After that, the blended raw material was charged into the sintering machine. In the sintering operation, the pallet moving speed was adjusted so that the sintering completion point could come to a position immediately before sintercake discharging section.

In Example 1a, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward in such a manner that pressure in a range from the igniting section to the position distant from the igniting section by 30% of the strand length was -1500 mmAq, and also pressure in a range from the position distant from the igniting section by 95% of the strand length to the sintercake discharging section was -1500 mmAq, and also pressure in a range from the position distant from the igniting section by 30% of the strand length to the position distant from the igniting section by 95% of the strand length was -2500 mmAq, and an upper portion of the raw material layer was open to the atmosphere. In this case, a mass flow rate in the range of the strand length of 30 to 95% with respect to the ranges except for the aforementioned range was 1.26, and a pressure drop in the layer thickness direction was 2500 mmAq.

In Example 1b, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward by the pressure of -1000 mmAq in the range from the igniting section to the sintercake discharging section. Pressure of 1500 mmAq was given to the inside of the pressure hood arranged in an upper portion of the raw mixture bed in the range from 30 to 95% of the strand length. In this case, a mass flow rate in the range of the strand length of 50 to 95% with respect to the ranges except for the aforementioned range was 1.27, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 1c, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward in such a manner that pressure in a range from the igniting section to the position distant from the igniting section by 30% of the strand length was -500 mmAq, and also pressure in a range from the position distant from the igniting section by 95% of the strand length to the sintercake discharging section was -500 mmAq. The pressure hood was continuously arranged in the aforementioned ranges, and pressure of 500 mmAq was given to the inside of the pressure hood. Gas was sucked downward in the range from 30 to 95% of the strand length by the negative pressure of -1000 mmAq, and the pressure of 2000 mmAq was given to the inside of the pressure hood. In this case, a mass flow rate in the range of the strand length of 30 to 95% with respect to the ranges except for the aforementioned range was 1.77, and a pressure drop in the layer thickness direction was 3000 mmAq.

In Example 1d, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward by the pressure of -1000 mmAq in the range from the igniting section to the sintercake discharging section. Exhaust gas before the stack was circulated in the pressure hood arranged in the range of 50 to 90% of the strand length and 10 to 90% in the width direction of the pallets, and the concentration of oxygen was adjusted to 18 vol% and the pressure of 1500 mmAq was given into the pressure hood. In this case, in the range of 50 to 90% of the strand length, a mass flow rate was 1.27 with respect to the ranges except for the aforementioned range, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 1e, sintering operation was conducted in the following conditions. The layer thickness was 550 mm. On the pallet, there were arranged four plate-shaped sintered ore supporting stands in the pallet width direction at regular intervals. Gas was sucked downward by the negative pressure of -1000 mmAq in the range from the igniting section to the sintercake discharging direction. The pressure of 1500 mmAq was given to the inside of the pressure hood arranged in the range of 50 to 90% of the strand length and 10 to 90% in the pallet width direction. In this case, in the range of 50 to 90% of the strand length, a mass flow rate was 1.27 with respect to the ranges except for the aforementioned range, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 1f, the layer thickness was 800 mm, and other conditions were the same as those of Example 1e. In this case, in the range of 50 to 90% of the strand length, a mass flow rate was 1.27 with respect to the ranges except for the aforementioned range, and a pressure drop in the layer thickness direction was 2500 mmAq.

In the comparative example, the same blended raw material as that of the inventive example was charged onto the pallets by the layer thickness of 550 mm, and the atmosphere was sucked in the range from the igniting section to the sintercake discharging section while the negative pressure of -1500 mmAq was kept constant, so that the blended raw material layer was sintered in the negative pressure according to the method of the conventional method.

On Table 1, the productivity of sintered ore, product yield, RDI and consumption unit of exhausted NOx are shown which were obtained in Comparative Example 1 and Inventive Examples 1a to 1f. In this case, unit requirement of exhausted NOx is expressed by the product of a volume of exhaust gas and a concentration of NOx contained in exhaust gas. As can be seen on Table 1, the productivities of Inventive Examples 1a to 1f are remarkably enhanced as compared with the productivity of Comparative Example. Conventionally, there was a tendency that the product yield was deteriorated when the productivity was enhanced, however, the product yield was also enhanced in the present invention. Further, RDI, JIS-RI (Reduction Index in JIS) and unit requirement of exhausted NOx were improved, that is, it was possible to provide excellent effects when iron ore was sintered, and the environment was kept in a good condition.

Table 1

	Comparative Example 1	Inventive Example					
		1a	1b	1c	1d	1e	1f
Productivity ($t/d/m^2$)	37.0	51.2	53.6	60.2	50.3	59.8	61.9
Product yield (%)	85.7	86.7	88.0	89.4	86.6	88.8	91.7
RDI (%)	35.0	33.8	33.2	32.9	33.5	31.0	32.6
JIS-RI (%)	68.3	72.3	73.9	74.8	73.5	76.8	75.3
Consumption unit of exhausted NOx (Nm^3/t)	0.32	0.31	0.27	0.26	0.31	0.25	0.26

EXAMPLE 2

Figs. 4 and 5 are schematic illustrations showing another example of the sintering machine of the present invention. Different points of this example from the example shown in Figs. 1 to 3 are that the main duct 9 is completely divided and the blowers 11, 15 are independently arranged. Further, the blower 29 may be arranged in this example. When a plurality of pressure patterns are set, a plurality of blowers may be arranged as described above.

Blended raw material used in this example was the same as that of Example 1, and the pallet moving speed was adjusted so that the sintering completion point could be the same position as that of the sintercake discharging section.

In Example 2a, sintering operation was conducted in the following conditions. Thickness of the raw mixture bed was 550 mm. Gas was sucked downward in such a manner that pressure was kept at -1000 mmAq in the range from the igniting section to a position distant from the igniting section by 50% of the strand length, and also pressure was kept at -1500 mmAq in the range from a position distant from the igniting section by 80% of the strand length to the sintercake discharging section. An upper portion of the raw mixture bed was open to the atmosphere. In the range from 50 to 80% of the strand length, gas was sucked downward at the pressure of -500 mmAq, and the pressure of 2000 mmAq was given to the inside of the pressure hood. In this case, in the range of 50 to 90% of the strand length, a mass flow rate was 1.52 with respect to the ranges except for the aforementioned range, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 2b, sintering operation was conducted in the following conditions. Thickness of the raw mixture bed was 550 mm. Gas was sucked downward at the negative pressure of -500 mmAq in the range from the igniting section to a position distant from the igniting section by 50% of the strand length, and the pressure hood was further arranged in this range, and pressure of 500 mmAq was given to the inside of the pressure hood. Gas was sucked downward at the negative pressure of -1000 mmAq in the range from a position distant from the igniting section by 80% of the strand length to the sintercake discharging section, and the pressure of 500 mmAq was given to the inside of the pressure hood. Gas was sucked downward at the negative pressure of -1500 mmAq in the range from 50 to 80% of the strand length, and the pressure of 1000 mmAq was given to the inside of the pressure hood. In this case, in the range of 50 to 80% of the strand length, a mass flow rate was 1.56 with respect to the ranges except for the aforementioned range, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 2c, the layer thickness was 800 mm, and other conditions were the same as those of Example 2a. In this case, in the range of 50 to 80% of the strand length, a mass flow rate was 1.52 with respect to the ranges except for the aforementioned range, and a pressure drop in the layer thickness direction was 2500 mmAq.

In Example 2d, the layer thickness was 800 mm. Four plate-shaped sintered ore supporting stands were arranged on the pallet in the pallet width direction at regular intervals. Other points of this example were the same as those of Example 2a. In this case, in the range of 50 to 80% of the strand length, a mass flow rate was 1.52 with respect to the ranges except for the aforementioned range, and a pressure drop in the layer thickness direction was 2500 mmAq.

In Comparative Example 1, sintering operation was conducted according to the method of the conventional method in which the same blended raw material as that of Examples 2a to 2d was used and the thickness of the raw mixture bed was set at 550 mm. The atmosphere was sucked at the negative pressure of -1500 mmAq in the range from the igniting section to the sintercake discharging section, so that the blended raw material layer was sintered in the negative pressure.

On Table 2, the productivity of sintered ore, product yield, RDI and consumption unit of exhausted NOx are shown which were obtained in Comparative Example 1 and Examples 2a to 2d. As can be seen on the second table, the productivities of Examples 2a to 2d are remarkably enhanced as compared with the productivity of the comparative example. Conventionally, there was a tendency that the product yield was deteriorated when the productivity was enhanced, however, the product yield was also enhanced in the present invention. Further, RDI, JIS-RI and consumption unit of exhausted NOx were improved, that is, it was possible to provide excellent effects when iron ore was sintered, and the environment was kept in a good condition.

In this connection, on the continued Table 2, there is shown a comparison between the example of the present invention and the method of the conventional method disclosed in Japanese Examined Patent Publication (Kokoku) No. 5-55574 described before. As can be seen on the following table, according to Example 2d of the present invention, it was possible to provide sintered ore, the characteristic of which was superior to that of sintered ore produced by the method of the conventional method.

Table 2

	Comparative Example 1	Inventive Example			
		2a	2b	2c	2d
Productivity ($t/d/m^2$)	37.0	54.0	54.5	62.3	65.8
Product yield (%)	82.2	86.9	88.2	93.4	92.0
RDI (%)	35.0	33.7	31.4	31.8	32.0
JIS-RI (%)	68.3	73.0	76.6	76.2	75.7
Consumption unit of exhausted NOx (Nm^3/t)	0.32	0.29	0.03	0.26	0.26

(continued Table 2)

	Present Invention		JP5-55574 gazette	
	Inventive example 2d	Comparative example 1	Inventive example	Method of the prior art
Exhaust gas energy (KWh/t-s)	10.02	14.47	12.44	13.64
Yield of sintered ore (%)	92.0	85.7	88.0	87.3
Sintered ore SI (%)	96.7	91.8	75.0	74.1
Sintered ore RDI (%)	32.0	35.0	33.3	34.8

EXAMPLE 3

The same sintering machine as that of Examples 1 and 2 was used in Example 3. For the purpose of producing sintered ore of low SiO_2, various iron ores, lime stone, quick lime, serpentine, scale, returned ore and coke breeze were adjusted so that SiO_2 contained in sintered ore could be 4.6 mass%, Al_2O_3 contained in sintered ore could be 1.85 mass% and the basicity of sintered ore could be 1.9. A ratio of returned iron ore to new raw material was determined to be 15% with respect to 100 of new raw material, and it was kept constant. A ratio of coke to new raw material was determined to be 3.5% with respect to 100 of new raw material, and it was kept constant. The composition of the comparative example and that of the inventive example were the same.

In Example 3a, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward in such a manner that pressure in a range from the igniting section to the position distant from the igniting section by 60% of the strand length was -1500 mmAq, and also pressure in a range from the position distant from the igniting section by 80% of the strand length to the ore discharging section was -1500 mmAq. The atmosphere was sucked downward in the range from 60 to 80% of the strand length at the negative pressure of -2500 mmAq. In this case, a mass flow rate in the range of the strand length of 60 to 80% with respect to the ranges except for the aforementioned range was 1.26, and a difference in pressure in the layer thickness direction was 2500 mmAq.

In Example 3b, sintering operation was conducted in the following conditions. Thickness of the raw mixture bed was 550 mm. Gas was sucked downward at the negative pressure of -1500 mmAq in the initial stage of sintering from the igniting section to the position distant from the igniting section by 60% of the strand length and also in the final stage of sintering from the position distant from the igniting section by 80% of the strand length to the sintercake discharging section. A portion of exhaust gas discharged from the above range was mixed with air so that the oxygen concentration could be 16 vol%, and the thus mixed gas was circulated into an upper portion of the pallet located in the range from 60 to 80% of the strand length and sucked downward at the negative pressure of -2500 mmAq. In this case, a mass flow rate in the range of the strand length of 60 to 80% with respect to the ranges except for the aforementioned range was 1.38, and a pressure drop in the layer thickness direction was 2500 mmAq.

In Example 3c, sintering operation was conducted in the following operational conditions. Thickness of the raw material layer was 550 mm. Gas was sucked downward in such a manner that pressure in a range from the igniting section to the position distant from the igniting section by 60% of the strand length was -500 mmAq, and also pressure in a range from the position distant from the igniting section by 80% of the strand length to the sintercake discharging section was -500 mmAq. The pressure hood was continuously arranged in the aforementioned ranges, and pressure of 500 mmAq was given to the inside of the pressure hood. Gas was sucked downward in the range from 60 to 80% of the strand length by the negative pressure of -1500 mmAq, and the pressure of 1000 mmAq was given to the inside of the pressure hood. The oxygen concentration of a portion of exhaust gas before the stack was adjusted to 16%, and gas was blown with pressure. In this case, a mass flow rate in the range of the strand length of 60 to 80% with respect to the ranges except for the aforementioned range was 1.56, and a pressure drop in the layer thickness direction was 2500 mmAq.

In Comparative Example 2, sintering operation was conducted according to the method of the conventional method in which the same blended raw material as that of Examples 3a to 3c was used and the thickness of the raw mixture bed was set at 550 mm. The atmosphere was sucked at the negative pressure of -1500 mmAq in the range from the igniting section to the sintercake discharging section, so that the blended raw material layer was sintered in the negative pressure.

On Table 3, the productivity of sintered ore, product yield of, RDI and unit requirement of exhausted NOx are shown which were obtained in Comparative Example 2 and Inventive Examples 3a to 3c. As can be seen on Table 3, the productivities of Inventive Examples 3a to 3c are remarkably enhanced as compared with the productivity of Comparative Example. Conventionally, there was a tendency that the product yield was deteriorated when the productivity was enhanced, however, the product yield was enhanced in the present invention. Further, RDI, JIS-RI and consumption unit of exhausted NOx were improved, that is, it was possible to provide excellent effects when iron ore was sintered, and the environment was kept in a good condition. At the same time, it was possible to produce low SiO_2 sintered ore.

Table 3

	Comparative example 2	Inventive example		
		3a	3b	3c
Productivity (t/d/m^2)	35.8	45.7	42.2	46.5
Product yield (%)	80.1	80.9	80.5	81.6
RDI (%)	35.4	33.2	33.8	33.9
JIS-RI (%)	65.6	74.6	72.7	72.5
Consumption unit of exhausted NOx (Nm^3/t)	0.34	0.30	0.26	0.27

In this connection, the negative pressure in the process of sintering, the oxygen concentration of sucked gas and the sucking time are not limited to the above specific examples, but it is possible to change them in accordance with the directivity to improvements in productivity and JIS-RI, and also in accordance with the directivity to suppression of exhausted NOx and decrease in the volume of exhaust gas.

According to the present invention, it is possible to greatly increase the thickness of a blended raw material layer and also it is possible to greatly increase the pallet moving speed which is difficult according to the method of the conventional method. Therefore, the productivity of a sintering machine can be greatly enhanced. Further, the product yield, RDI and JIS-RI can be improved by the present invention, and further a volume of exhaust gas can be decreased. As described above, it is possible for the present invention to provide the effects, which are incompatible with each other according to the method of the conventional method, at the same time, that is, the effects provided by the present invention are very great.

EXPLANATION OF THE REFERENCES

1	Blended sintering material
2	Surge hopper
3	Drum feeder
4	Sprocket
5	Raw material charging device
6	Pallet
7	Raw mixture bed
8	Wind box
9	Main duct
10	Exhaust gas dust collector
11	Blower
12	Stack
13	Sub-duct
14	Exhaust gas dust collector
15	Blower
16	Damper
17	Exhaust gas dust collector
18	Blower
19	Pressure hood
21	Sintered ore supporting stand
22	Grate bar
23	Sealing mechanism
24	Sheet
25	Sponge
26	Blower
27	Ignition furnace

Claims

1. A method of producing sintered ore, the product yield and the product quality of which are high, comprising the steps of:

charging blended raw material containing fine ore, flux and fuel onto pallets of a sintering machine so as to form a raw mixture bed on the pallets; and

subsequently igniting a surface layer of the raw mixture bed so as to cause a sintering reaction on the raw mixture bed in the direction from an upper portion to a lower portion, wherein when the upper layer of the raw material has been sufficiently sintered, a mass flow rate of gas containing oxygen supplied onto the raw mixture bed is changed to a value 1.01 to 2.6 times as high as that of gas containing oxygen supplied in the sintering of the upper layer of the raw material.

2. A method of continuously producing sintered ore, the product yield and the product quality of which are high, comprising the steps of:

charging blended raw material containing powder ore, flux and fuel onto pallets of a sintering machine so as to form a raw mixture bed on the pallets; and

subsequently igniting a surface layer of the raw mixture bed while a combustion and melting zone is being moved from an upper portion to a lower portion, wherein when an end of a forming range of the combustion and melting zone has reached a position lower than a position located at 20% of the height of the raw mixture bed from the surface layer, a mass flow rate of gas containing oxygen supplied onto the raw mixture bed is changed to a value 1.01 to 2.6 times as high as that of gas containing oxygen supplied in the range of sintering of the raw mixture bed before reaching said position.

3. A method of producing sintered ore according to claim 1 or 2, further comprising the steps of:

arranging a pressure hood for giving pressure to gas containing oxygen on the raw mixture bed on the sintering pallets;
giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure; and
sucking gas from a lower portion of the raw mixture bed by the negative pressure of -2000 to -1 mmAq with respect to the atmospheric pressure.

4. A method of producing sintered ore according to any one of claims 1 to 3, further comprising the steps of:

arranging a pressure hood for giving pressure to gas containing oxygen in a range from 5 to 95% in the pallet width direction on the raw mixture bed on the sintering pallets; and
giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure.

5. A method of producing sintered ore according to claim 3 or 4, further comprising the steps of:

arranging a pressure hood for giving pressure to gas containing oxygen on the raw material layer in a range after an end of a forming range of the combustion and melting zone has reached a position located at 20% of the height of the raw mixture bed from the surface layer; and
giving pressure of 100 to 3000 mmAq to gas in the pressure hood with respect to the atmospheric pressure.

6. A method of producing sintered ore according to any one of claims 3 to 5, wherein sintering exhaust gas is circulated in the pressure hood for giving pressure to gas containing oxygen arranged on the raw mixture bed layer.

7. A method of producing sintered ore according to any one of claims 1 to 6, wherein sintering is conducted on iron ore by a Dwight Lloyd type sintering machine in which a plurality of plate-shaped sintered ore supporting stands are arranged on the grates of the sintering pallets substantially in parallel with the pallet advancing direction.

8. A method of producing sintered ore according to any one of claims 1 to 7, wherein sintered ore containing SiO_2 of 3.9 to 4.9 mass% in chemical composition is produced by the method.

9. A method of producing sintered ore according to any one of claims 1 to 8, wherein layer thickness of the raw mixture bed layer is 600 to 1500 mm.

10. A sintering machine of down-suction type comprising:

a plurality of wind boxes arranged in a lower portion of the sintering strand, the wind boxes being connected with a suction duct in parallel with each other;
a main blower arranged in the suction duct; and
another blower for sucking gas from the duct in a range from 30% of the length from the igniting section to the sintercake discharging section, to the sintering completion point, and for discharging gas into the suction duct.

11. A sintering machine comprising:

a plurality of wind boxes arranged in a lower portion of the sintering strand, the wind boxes being connected with a suction duct in parallel with each other, wherein the suction duct is divided into a range from 30% of the length of the strand from the igniting section to the sintercake discharging section, to the sintering completion point, and into a residual range; and
blowers independently arranged in the ranges.

12. A sintering machine according to claim 10 or 11, further comprising a pressure hood for feeding and compressed gas containing oxygen, arranged on the raw mixture bed on the sintering pallets.

13. A sintering machine according to claim 10 or 11, further comprising a pressure hood for supplying and compressed gas containing oxygen, arranged on the raw mixture bed in a range in which an end of a forming range of the combustion and melting zone has reached a position located lower than the surface layer of the raw mixture bed by a distance of 20% of the height of the raw mixture bed.

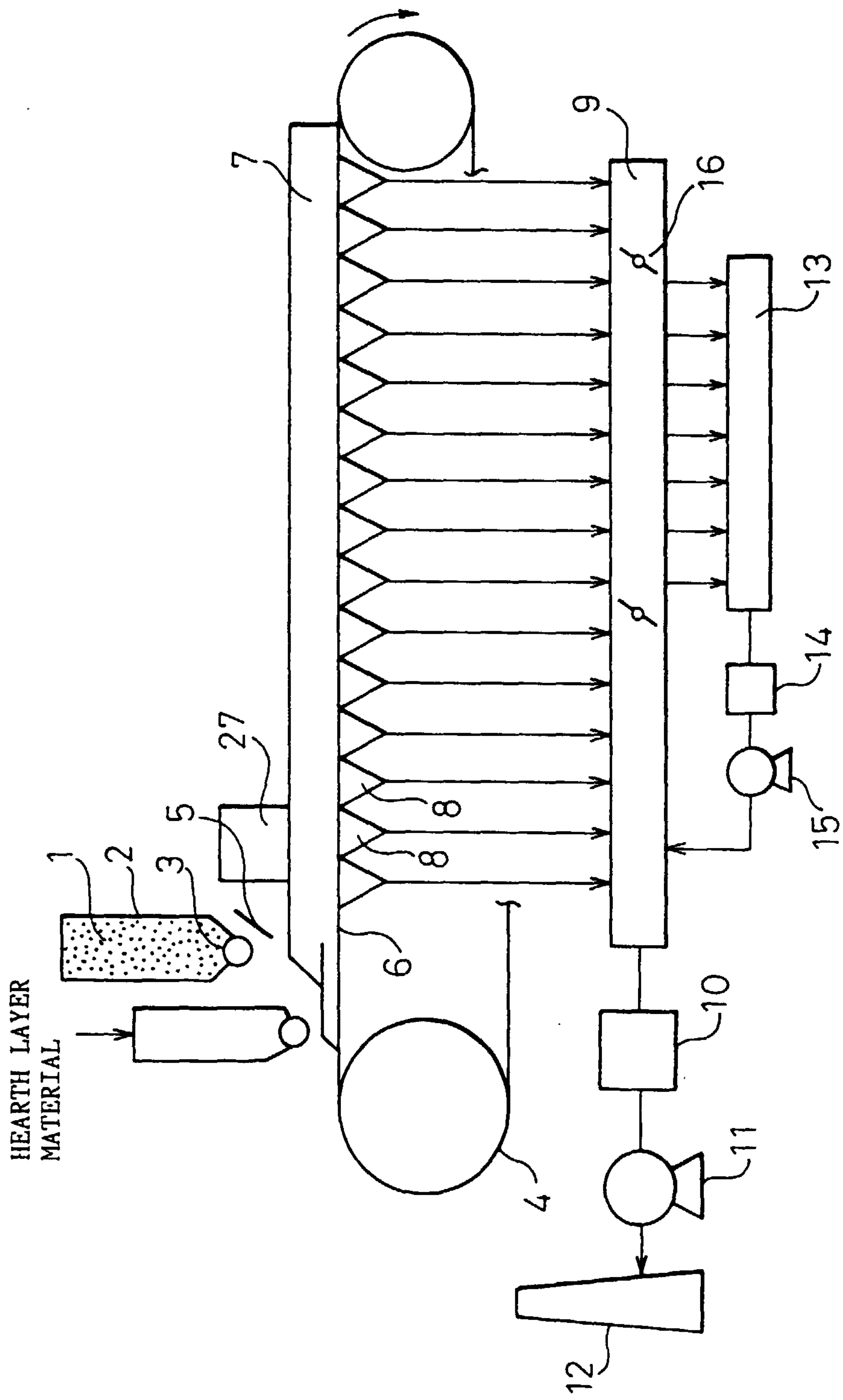
14. A sintering machine according to claim 12 or 13, further comprising a pressure hood for supplying and compressed gas containing oxygen, arranged on the raw mixture bed on the sintering pallets in a range of 5 to 95% in the pallet width direction.

15. A sintering machine according to any one of claims 12 to 14, wherein sintering exhaust gas is circulated in the pressure hood for supplying and compressed oxygen arranged on the raw mixture bed layer.

16. A sintering machine according to any one of claims 12 to 15, wherein a sealing mechanism is arranged in a lower end portion of the pressure hood for supplying and compressed gas containing oxygen.

17. A sintering machine of the down-suction type according to any one of claims 10 to 16, further comprising a plurality of plate-shaped sintered ore supporting stands arranged on the grates of the sintering pallets substantially in parallel with the pallet advancing direction.

Fig.1



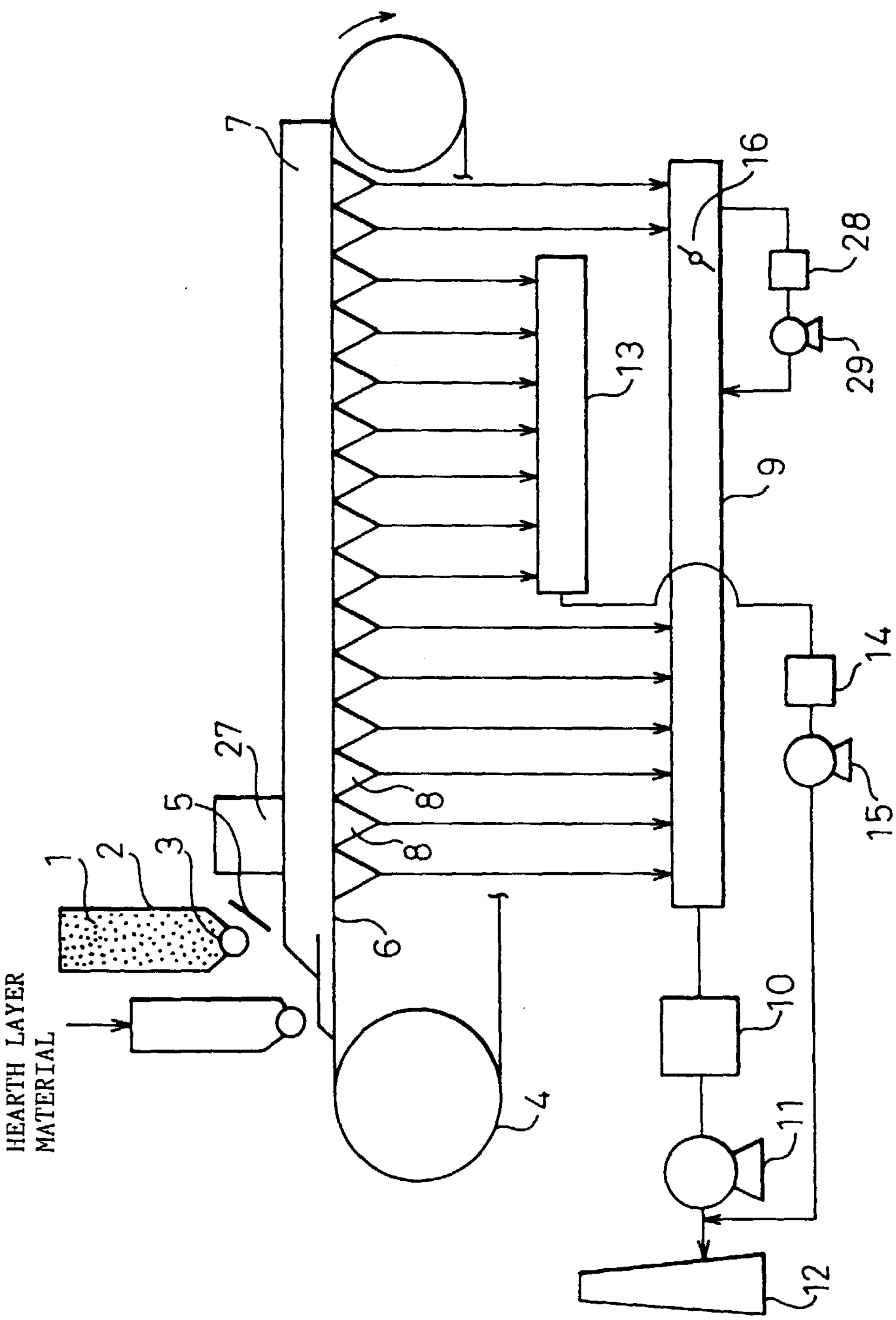

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Fig.2

Fig.3

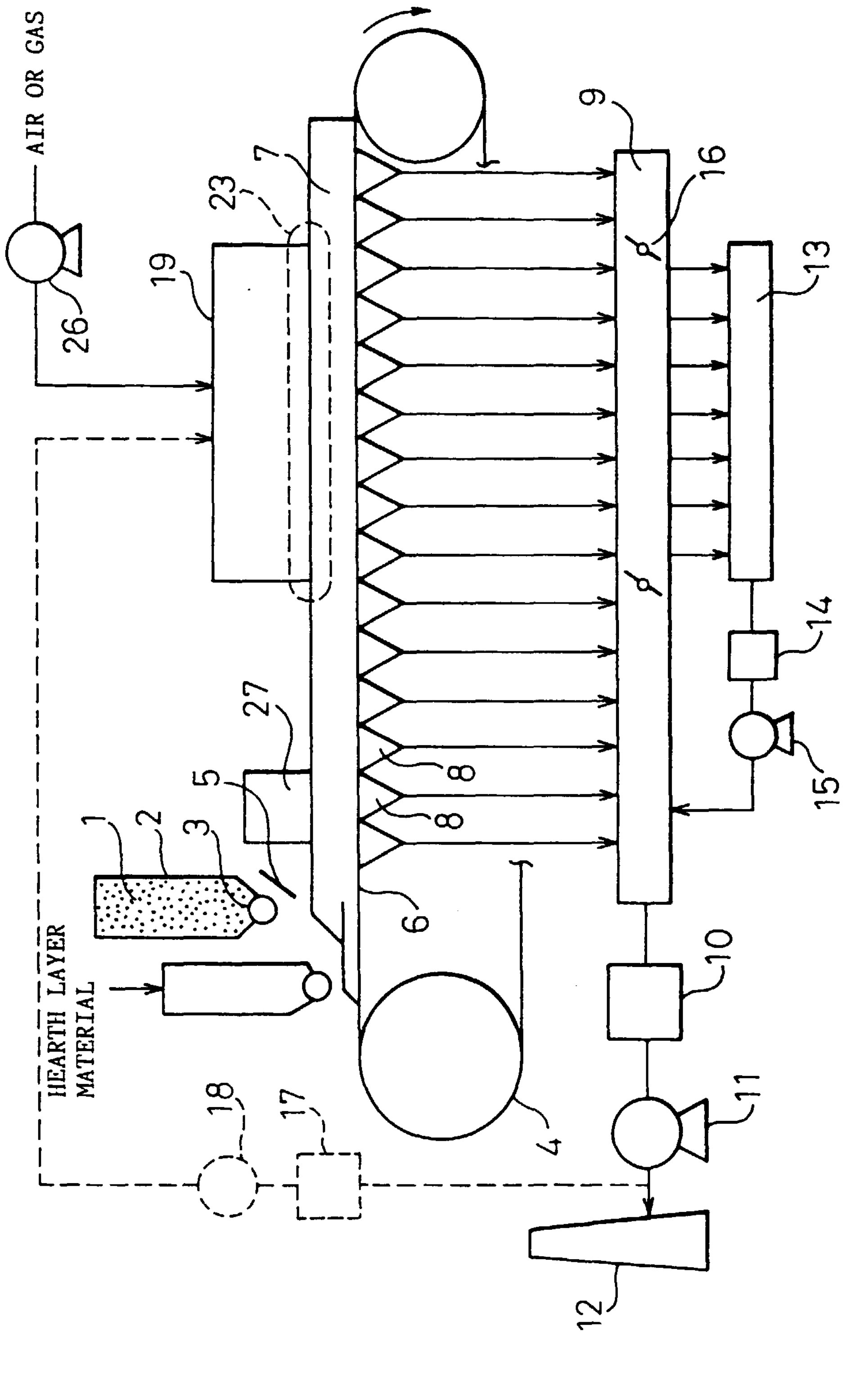
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Fig.4

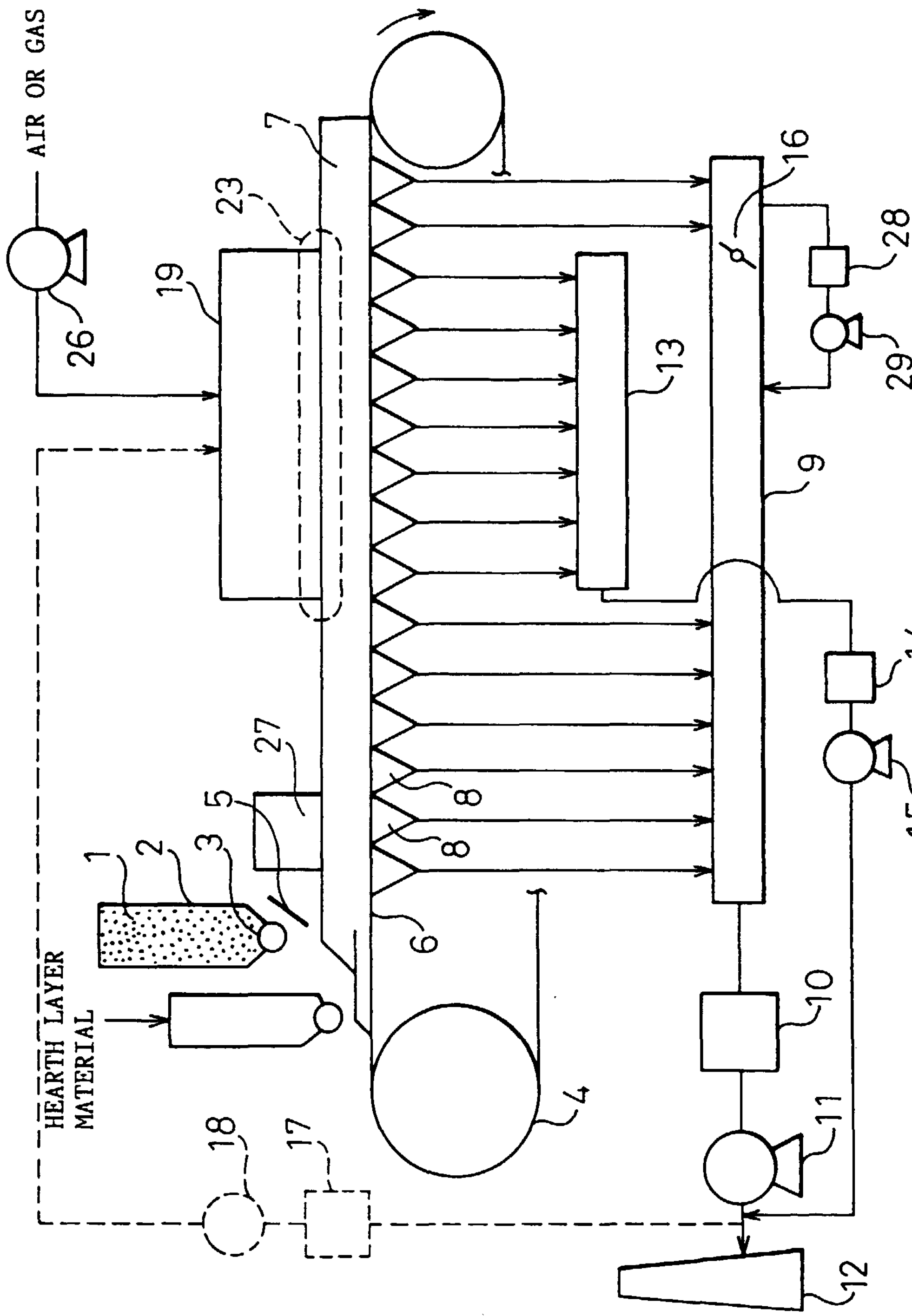
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Fig.5

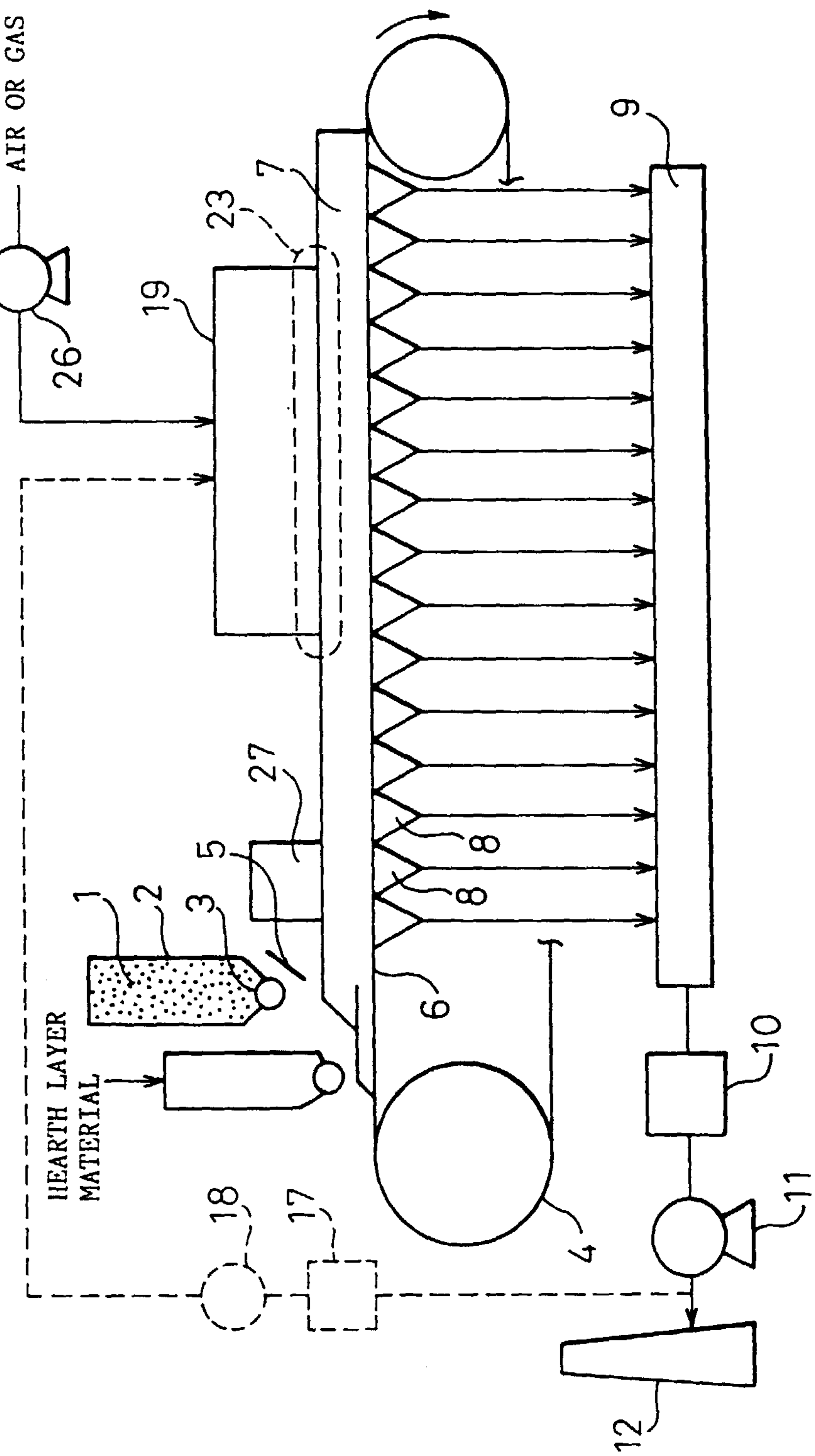
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Fig.6

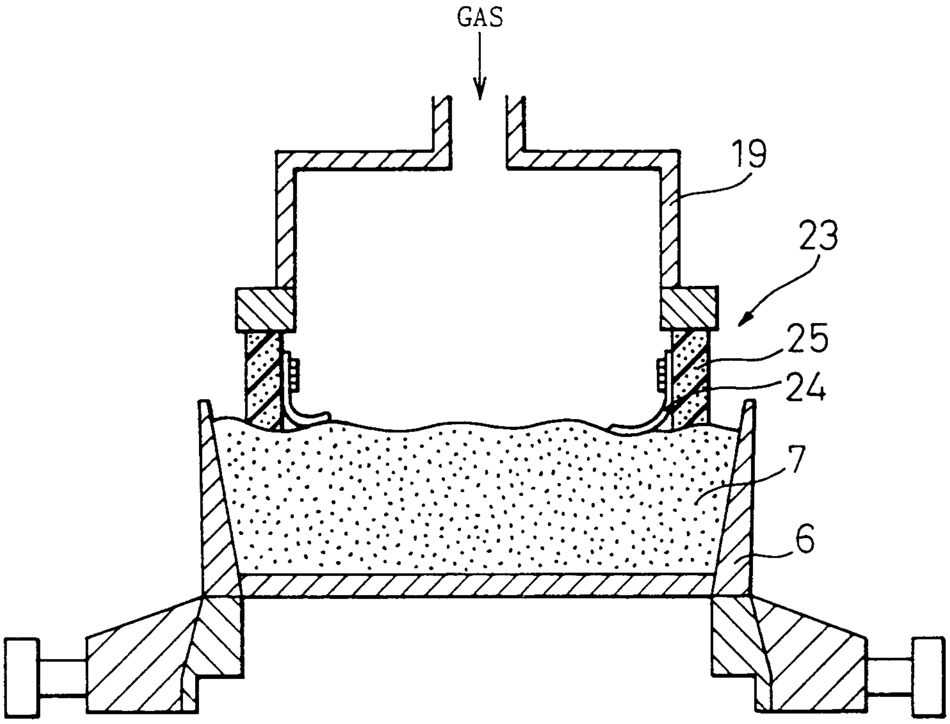


Fig.7

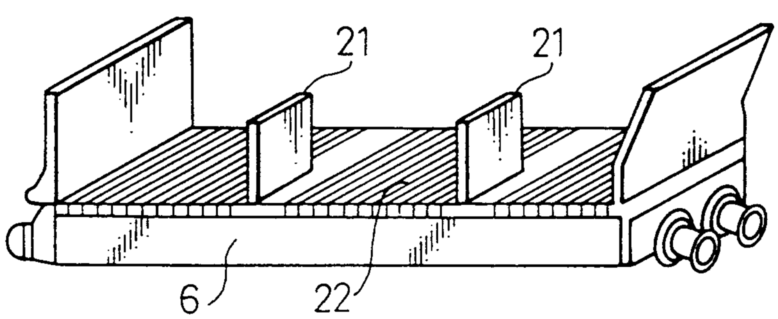


Fig.8(a)

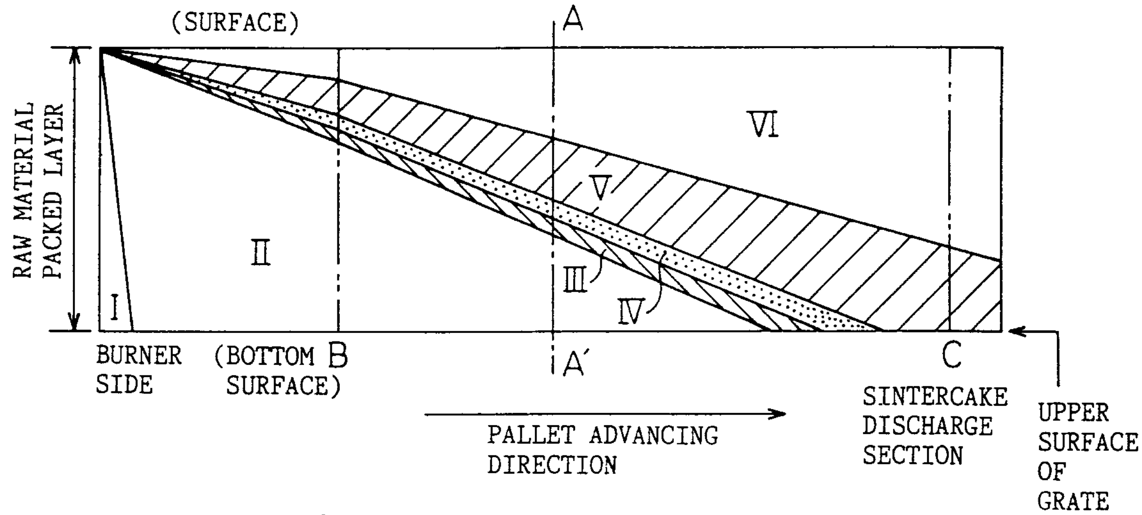


Fig.8(b)

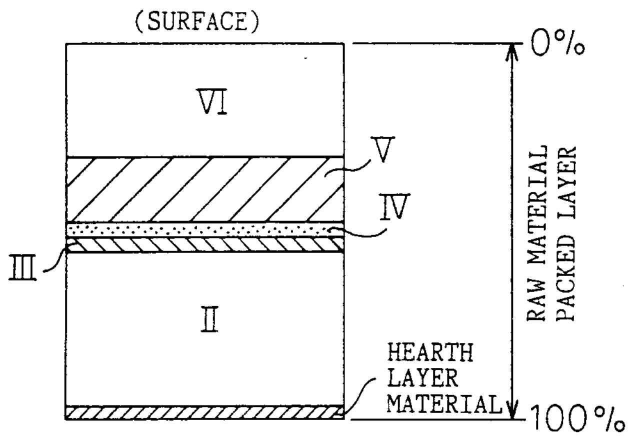
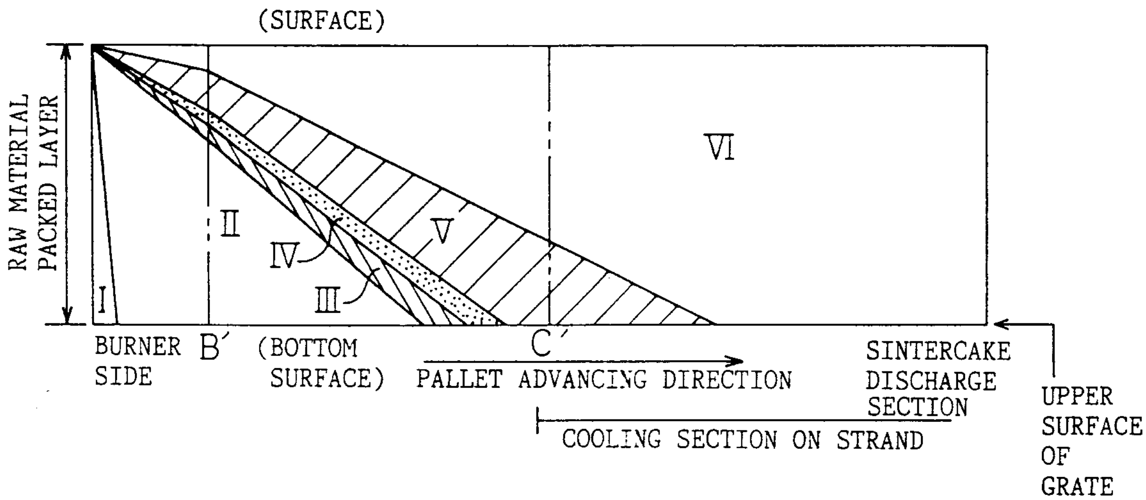


Fig.8(c)



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/02843

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl[6] C22B1/20

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

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

Jitsuyo Shinan Koho 1926 - 1996
Kokai Jitsuyo Shinan Koho 1971 - 1997
Toroku Jitsuyo Shinan Koho 1994 - 1997
Jitsuyo Shinan Toroku Koho 1996 - 1997

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 8-100222, A (Nippon Steel Corp.), April 16, 1996 (16. 04. 96), Page 2, claim; Fig. 1 (Family: none)	1 - 17
A	JP, 5-247546, A (Metal AG.), September 24, 1993 (24. 09. 93), Page 2, claim & EP, 535727, A1 & US, 5476533, A	1 - 17
A	JP, 5-43951, A (Nippon Steel Corp.), February 23, 1993 (23. 02. 93), Page 2, claim; Fig. 1 (Family: none)	1 - 17
A	JP, 2-73924, A (Nippon Steel Corp.), March 13, 1990 (13. 03. 90), Page 2, claim; Fig. 1 (Family: none)	1 - 17

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

- * Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
November 11, 1997 (11. 11. 97)	November 18, 1997 (18. 11. 97)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)