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(54) **PROCESS FOR PRODUCING SINTERED ORE AND SINTERING APPARATUS**

VERFAHREN ZUR HERSTELLUNG VON GESINTERTEM ERZ UND SINTERVORRICHTUNG

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method for producing a sintered ore and a sintering machine, each of which produces a sintered ore.

DESCRIPTION OF RELATED ARTS

[0002] A sintered ore which is a main raw material of a blast furnace iron making process is produced generally by a process illustrated in Fig. 15. As raw materials for the sintered ore, for example, there may be mentioned a fine iron ore, recovered fine in steel works, under-sieve fine of a sintered ore (returned ore), a CaO-containing auxiliary raw material such as limestone and dolomite, an agglomeration assistant such as burnt lime, coke fine, and anthracite. These raw materials are supplied from a plurality of hoppers 1 onto a conveyer at a predetermined ratio. The supplied raw materials are blended together and agglomerated in a drum mixer 2, a. rotary kiln 3, and the like with the addition of an adequate amount of water, thus forming a sintering raw material which is quasi-particles having an average particle size in a range of 3.0 and 6.0 mm. In addition, a particle-size regulated lump ore is supplied from a hearth hopper 4 to form a hearth layer on a grate of a sintering machine pallet 8.

[0003] The sintering raw material is charged onto the hearth layer on the endless traveling sintering machine pallet 8 from a surge hopper 5 located above a sintering machine through a drum feeder 6 and a charge chute 7, thereby forming a charged bed 9, which is also called a sintering bed, of the sintering raw material. The thickness (height) of the sintering bed is generally in a range of approximately 400 to 800 mm. Then, a carbonaceous material in a surface layer of this sintering bed 9 is ignited by an ignition furnace 10 positioned above the sintering bed 9, and at the same time, downward air suction is performed using wind boxes 11 located below the pallet 8, so that the carbonaceous material in the sintering bed is successively combusted. By combustion heat generated at this stage, the sintering raw material is combusted and melted, thereby forming a sintered cake. Subsequently, the sintered cake thus obtained is crushed and regulated in size, thereby being collected as a product sintered ore composed of agglomerates having a size of 5.0 mm or more.

[0004] According to the above producing process, first, the ignition furnace 10 ignites the surface layer of the sintering bed. The carbonaceous material thus ignited in the sintering bed has a certain width and is continuously combusted by suction air sucked from an upper layer portion of the sintering bed down to a lower layer portion thereof by the window boxes, and this combustion zone gradually propagates to a lower layer and forward (downstream side) as the pallet 8 travels. With the progress of this combustion, moisture contained in the sintering raw material particles of the sintering bed is vaporized by heat generated by the combustion of the carbonaceous material and is then sucked downward; hence, the moisture thus sucked downward is condensed in a sintering raw material located in the lower layer at which the temperature is not increased yet, and as a result, a wet zone is formed. When the moisture concentration increases to a certain extent or more, voids among the raw material particles, which function as paths of a suction gas, are filled with the moisture, thereby increasing a gas flow resistance. In addition, a melting portion which is necessary for a sintering reaction generated in the combustion zone also causes an increase in gas flow resistance.

[0005] A production rate (t/hr) of a sintering machine is generally determined by a sinter productivity ($t/hr\cdot m^2$)×the area of the sintering machine (m^2). That is, the production rate of a sintering machine varies with the width and length thereof, the thickness of a raw material charged layer (the thickness of a sintering bed), the bulk density of a sintering raw material, a sintering (combustion) time, a yield, and the like. In addition, in order to increase the production rate of a sintered ore, for example, it is believed that a decrease in sintering time by improvement in gas permeability (pressure loss) of the sintering bed or an improvement in yield by an increase in cold strength of a sintered cake before being crushed are effective.

[0006] FIG. 16 is a graph showing the pressure loss and the temperature distribution in a sintering bed having a thickness of 600 mm, this graph being obtained when a front line of a combustion zone moving in the sintering bed reaches a position therein approximately 400 mm above a pallet (the position approximately 200 mm below the surface of the sintering bed). The pressure loss distribution at that moment is approximately 60% in a wet zone and approximately 40% in a combustion and melting zone.

[0007] FIG. 17 shows the temperature distribution in a sintering bed at high productivity of a sintered ore and that at low productivity thereof, that is, at a high pallet traveling speed and a low pallet traveling speed. A holding time (hereinafter referred to as " holding time in a high-temperature region") in a temperature zone in which the temperature is maintained at 1,200°C or more at which raw material particles begin to melt is expressed by t_1 in the case of the low productivity and by t_2 in the case of the high productivity which emphasizes the productivity. In the case of the high productivity, since the pallet traveling speed is fast, the holding time t_2 in a high-temperature region is shorter than t_1 in the case of the low productivity. When the holding time in a high-temperature region is decreased, insufficient sintering is liable to occur, the cold strength of a sintered ore decreases, and the yield decreases. Accordingly, in order to increase the productivity of a high-strength sintered ore, there must be used some type of method in which even if the sintering is performed for a short time, the strength of a sintered cake, that is, the cold strength of a sintered ore, is increased, and in which the yield can be maintained or improved. In addition, as the indices indicating the cold strength of a sintered ore, in general, SI (shutter index) and TI (tumbler index) have been used.

[0008] Fig. 18(a) shows a proceeding process of sintering in a sintering bed on a sintering machine pallet; Fig. 18(b) shows the temperature distribution (heat pattern) in a sintering process in the sintering bed; and Fig. 18(c) shows a yield distribution of a sintered cake. As apparent from Fig. 18(b), the temperature in an upper portion of the sintering bed is not likely to increase as compared to that in a lower layer portion thereof, and the holding time in a high-temperature region is also decreased. Accordingly, in the upper portion of the sintering bed, a combustion and melting reaction (sintering reaction) is not sufficiently performed, and the strength of the sintered cake is decreased; hence, as shown in Fig. 18(c), the yield is low, and as a result, the productivity is decreased.

[0009] In consideration of the problems described above, heretofore, a method in which the upper layer portion of the sintering bed is maintained at a high temperature for a long time has been proposed. For example, Patent Document 1 has disclosed a technique in which after a sintering bed is ignited, a gas fuel is sprayed thereon. However, although the type of gas fuel (flammable gas) has not been disclosed in the above technique, even if it is a propane gas (LPG) or a natural gas (LNG), a gas at a high concentration is used. Furthermore, since the amount of a carbonaceous material is not decreased when the flammable gas is sprayed, the temperature inside a sintering layer is increased to as high as more than 1,380°C. Hence, by the technique described above, a sufficient improvement in cold strength and/or an effect of improving the yield has not been obtained. In addition, when a flammable gas is sprayed just behind an ignition furnace, by combustion of the flammable gas, the probability of occurrence of a fire accident in a space above a sintering bed is high, and hence, the technique is not realistic and has not been practically used.

[0010] In addition, Patent Document 2 has also disclosed a technique in which, after a sintering bed is ignited, a flammable gas is added to air sucked into the sintering bed. Although it has been disclosed that a supply is preferably performed approximately 1 to 10 minutes after the ignition, since a red-hot sintered ore remains in a surface layer portion immediately after the ignition by an ignition furnace, the probability of causing a fire accident by combustion of the flammable gas is high depending on the way of the supply thereof, and although there has not been so many concrete descriptions, even when a flammable gas is combusted in a sintering zone which is already sintered, the effect cannot be obtained. In addition, when combustion is performed in the sintering zone, since the gas permeability is degraded by an increase in temperature by the flammable gas and a thermal expansion thereof, the productivity tends to decrease, and furthermore, since the amount of a carbonaceous material is not decreased when the flammable gas is sprayed, the temperature inside the sintering layer is increased to as high as more than 1,380°C. Hence, since a sufficient improvement in cold strength and an effect of improving the yield cannot be obtained by this technique, this technique has not been practically used at present.

[0011] In addition, Patent Document 3 has disclosed a technique in which in order to obtain a high temperature inside a sintering bed of a sintering raw material, a hood is provided above the sintering bed and a mixed gas of air and a coke oven gas is sprayed at a position just behind an ignition furnace through the hood. However, since the temperature of a combustion and melting zone in a sintering layer is also increased to as high as more than 1,380°C by this technique, an effect of spraying a coke oven gas cannot be obtained, and if a flammable mixed gas ignites in a space above a sintering bed, a fire accident may occur with a high probability; hence, this technique has not been practically used.

[0012] Furthermore, Patent Document 4 has disclosed a method of simultaneously spraying a low-melting point solvent, a carbonaceous material, and a flammable gas at a position just behind an ignition furnace. However, in this method, since the flammable gas is sprayed while flame remains on a surface, the probability of causing a fire accident in a space above a sintering bed is high, and since the width of a sintering zone cannot be sufficiently increased (approximately less than 15 mm), an effect of spraying a flammable gas cannot be fully obtained. In addition, since a large amount of the low melting-point solvent exists, an excessive melting phenomenon occurs at an upper layer portion, and voids each functioning as an air flow path are clogged; hence, the gas permeability is degraded, and the productivity is degraded. Consequently, this technique has also not been practically used at present.

[0013] As thus has been described, the conventional techniques thus proposed all have serious problems against practical use thereof, and development of a practical technique of spraying a flammable gas has been strongly desired.

[0014] As a technique capable of solving the above problems, the present applicant proposed a method disclosed in Patent Document 5 in which various types of gas fuels diluted to not more than a lower limit concentration of combustion is supplied from above a sintering bed of a sintering raw material deposited on a pallet of a sintering machine and is introduced into the sintering bed, and by the combustion, at least one of an ultimate maximum temperature in the sintering bed and a holding time in a high-temperature zone is controlled.

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 48-18102
[Patent Document 2] Japanese Examined Patent Application Publication No. 46-27126
[Patent Document 3] Japanese Unexamined Patent Application Publication No. 55-18585

[Patent Document 4] Japanese Unexamined Patent Application Publication No. 5-311257
[Patent Document 5] International Publication No. WO 2007-052776

[0015] JP S56-51536 discloses a method for producing a sintered ore using a downward section type sintering machine comprising forming a sintering bed and blowing vaporized waste oil onto the surface of the sintering bed after the ignition.

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0016] According to the technique disclosed in Patent Document 5, in a downward suction type sintering machine, since a gas fuel supply is performed such that a gas fuel diluted to a predetermined concentration is supplied (introduced) into the sintering bed and is combusted at a targeted position therein, the ultimate maximum temperature in combustion of the sintering raw material and the holding time in a high-temperature zone can be appropriately controlled, and as a result, operation can be performed so as to increase a sintered ore strength not only in an upper layer portion of the sintering bed in which the cold strength of a sintered ore is liable to decrease due to insufficient heat quantity but also in an arbitrary portion in or below a middle layer portion of the sintering bed.
[0017] However, when the above operation of gas fuel supply sintering is performed, a gas fuel may be combusted (ignited) in some cases by a backfire caused by a high temperature portion, such as a crack portion of a sintering bed and/or a sintered cake, which functions as a live coal. When the sintering operation is continued in the ignition state as described above (an explosion accident is separated from this case), the gas fuel cannot be supplied in the sintering bed, and in addition, since oxygen is consumed by the combustion of the gas fuel, air containing an insufficient amount of oxygen is supplied (introduced) into the sintering bed. As a result, since the ultimate maximum temperature in the combustion and the holding time in a high temperature zone cannot be controlled, and further insufficient combustion occurs, the strength of a sintered ore is decreased, and the yield and the productivity are degraded, so that the sintering operation is seriously and adversely influenced.
[0018] Accordingly, the present invention was made in consideration of the problems of the above conventional examples, and an object of the present invention is to provide a method for producing a sintered ore in which a high-strength and high-quality sintered ore can be safely produced with high yield by a downward suction type sintering machine and is to provide a sintering machine.

MEANS FOR SOLVING THE PROBLEMS

[0019] To achieve the object, the present invention provides a method for producing a sintered ore which includes a charging step of forming a sintering bed, an ignition step, a liquid fuel supply step of supplying a liquid fuel on the sintering.bed, and a sintering step.
[0020] The charging step comprises charging a sintering raw material containing a fine ore and a carbonaceous material onto a circular traveling pallet to form a sintering bed. The ignition step comprises igniting the carbonaceous material in the formed sintering bed by an ignition furnace. The liquid fuel supply step comprises supplying an atomized liquid fuel having a particle size of 100 μm or less above the sintering bed after the ignition. The sintering step comprises sucking air by a wind box disposed below the pallet to produce the sintered ore.
[0021] The atomized liquid fuel preferably has a particle size in a range of 20 to 50 μm. The atomized liquid fuel preferably has a concentration of not more than a lower limit concentration of combustion. The concentration is preferably in a range of 1% to 75% of the lower limit concentration of combustion. The concentration is most preferably in a range of 4% to 25% of the lower limit concentration of combustion.
[0022] The liquid fuel supply step is preferably as follows.

(A) The liquid fuel supply step comprises supplying an atomized liquid fuel having a particle size of 100 μm or less above the sintering bed and supplying the atomized liquid fuel into the sintering bed in a condition that the atomized liquid fuel is diluted to not more than a lower limit concentration of combustion at ordinary temperature.
(B) The liquid fuel supply step comprises spraying an atomized liquid fuel having a particle size of 100 μm or less to an upper side of the sintering bed.
(C) The liquid fuel supply step comprises: mixing a liquid fuel and a compressed gas to form an atomized liquid fuel; and spraying the atomized liquid fuel above the sintering bed. The compressed gas is a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component.

[0023] The liquid fuel is preferably at least one selected from the group consisting of a petroleum-based liquid fuel, an alcohol-based liquid fuel, an ether-based liquid fuel, and another hydrocarbon-based liquid fuel. The petroleum-based liquid fuel is preferably at least one selected from the group consisting of lamp oil, light oil, and heavy oil. The alcohol-based liquid fuel is preferably at least one selected from the group consisting of methyl alcohol, ethyl alcohol, and diethyl alcohol. The another hydrocarbon-based liquid fuel is preferably at least one selected from the group consisting of pentane, hexane, heptane, octane, nonane, decane, benzene, and acetone.

[0024] The liquid fuel is preferably supplied at any of the following positions.

(a) The atomized liquid fuel is supplied from the formation of a sintered cake in a surface layer portion of the sintering bed to the completion of sintering.
(b) The atomized liquid fuel is supplied in a region in which the thickness of a combustion and melting zone is 15 mm or more.
(c) The atomized liquid fuel is supplied after a combustion front reaches a position located 100 mm below a surface layer.

[0025] Furthermore, the present invention provides a sintering machine which includes: a circular traveling pallet; a raw material supply device charging a sintering raw material containing a fine ore and a carbonaceous material on the pallet to form a sintering bed; an ignition furnace igniting the carbonaceous material in the sintering raw material on the pallet; a liquid fuel spray device which is provided at a downstream side of the ignition furnace and which atomizes a liquid fuel to have a particle size of 100 μm or less and sprays the atomized liquid fuel above the sintering bed; and a wind box sucking air to a lower side of the pallet.

[0026] The liquid fuel spray device includes: a compressed gas supply source, a liquid fuel supply source, and a spray mechanism which mixes a liquid fuel from the liquid fuel supply source and a compressed gas from the compressive gas supply source to form an atomized liquid fuel and which sprays the atomized liquid fuel above the sintering bed in a horizontal direction. The compressed gas is preferably a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component. The spray mechanism preferably includes: a transport pipe which transports a mixed fluid of the compressed gas and the liquid fuel and which has a downward slope toward a downstream side; a communicating pipe communicating with the transport pipe at a lower surface side thereof; and a spray nozzle which is formed at a lower surface of the communicating pipe, sprays the liquid fuel in a horizontal direction, and has a downward slope toward an ejection port. The liquid fuel spray device preferably includes a pre-heating mechanism for pre-heating the liquid fuel so that when having a high viscosity, the liquid fuel has an optimal viscosity for atomization thereof.

[0027] The liquid fuel is preferably at least one selected from the group consisting of a petroleum-based liquid fuel, an alcohol-based liquid fuel, an ether-based liquid fuel, and another hydrocarbon-based liquid fuel, each of which is in a liquid state at approximately ordinary temperature. Advantages

[0028] According to the method for producing a sintered ore of the present invention, since the liquid fuel which is atomized to have a particle size of 100 μm or less is supplied to an upper portion of the sintering bed at a downstream side of the ignition furnace and is supplied into the sintering bed from thereabove while being diluted to not more than the lower limit concentration of combustion at ordinary temperature, by air suction by the wind box, the liquid fuel is vaporized in an upper layer portion of the sintering bed and is then transported to a combustion and melting zone located in a lower layer of the sintering bed without causing combustion of the liquid fuel on the sintering bed, and hence, the liquid fuel is combusted as a gas fuel. Accordingly, as in the case of using a gas fuel, when the supply position of the atomized liquid fuel, the ultimate maximum temperature in combustion, and the holding time in a high-temperature region are controlled, operation can be performed so as to increase a sintered ore strength not only at an upper portion of the sintering bed in which the cold strength of a sintered ore is liable to decrease due to insufficient combustion but also at an arbitrary portion in or below a middle layer of the sintering bed. In this case, when the particle size of the liquid fuel is more than 100 μm, since a part thereof remains in the surface layer portion of the sintering bed, the combustion starts in the surface layer portion, and the liquid fuel is increasingly wastefully used, so that an effect of increasing the holding time in a high-temperature region is decreased. When the particle size is 100 μm or less, the liquid fuel is suppressed from being combusted on the sintering bed and in the surface layer portion thereof, is vaporized after introduced into the sintering bed, and is sucked to the lower layer portion so as to reach the combustion and melting zone; hence, the liquid fuel can be combusted as a gas fuel.

[0029] In this case, the particle size of the atomized liquid fuel is preferably selected in a range of 20 to 50 μm, and when the particle size is selected to 50 μm or less, the atomized liquid fuel can be reliably introduced into the combustion and melting zone in the sintering bed. Although a smaller particle size of the atomized liquid fuel is more preferable, since a generation amount thereof is decreased as the particle size is decreased, in consideration of a generation amount required for increasing the holding time in a high-temperature region, the particle size is preferably selected to 20 μm or more.

[0030] According to the sintering machine of the present invention, since the liquid fuel spray device which atomizes and sprays the liquid fuel above the sintering bed in a horizontal direction is provided at a downstream side of the ignition furnace, the liquid fuel atomized and sprayed by this liquid fuel spray device is uniformly dispersed on the sintering bed, and the atomized liquid fuel thus uniformly dispersed is sucked into the sintering bed by the wind box. Hence, the liquid fuel is vaporized in the sintering bed, and as in the case of using a gas fuel, when the supply position of the atomized liquid fuel, the ultimate maximum temperature in combustion, and the holding time in a high-temperature region are controlled, operation can be performed so as to increase a sintered ore strength not only in an upper portion of the sintering bed in which the cold strength of a sintered ore is liable to decrease due to insufficient combustion but also at an arbitrary portion in or below a middle layer of the sintering bed. Furthermore, since the liquid fuel is atomized and is then sprayed on the sintering bed, no ignition or the like may occur unlike the case of using the liquid fuel itself, and the atomized liquid fuel can be safely and stably introduced into the raw material sintering bed.

[0031] Furthermore, as the compressed gas which atomizes the liquid fuel, when at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor is used, the combustion on the sintering bed can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

Fig. 1 is a schematic structural view showing one embodiment of a sintering machine according to the present invention.
Fig. 2 is a schematic cross-sectional view taken along the line A-A shown in Fig. 1.
Fig. 3 is a front view showing a spray mechanism.
Fig. 4 is a schematic perspective view showing a spray mechanism placement of a liquid fuel spray device.
Fig. 5 is an explanation view showing a liquid fuel-mist spray state of the liquid fuel spray device.
Fig. 6 is a system diagram showing a supply system of a liquid fuel and a compressed gas of the liquid fuel spray device.
Fig. 7 is a cross-sectional view showing a concrete structure of the liquid fuel spray device taken along the line A-A shown in Fig. 1.
Fig. 8 is an explanation view showing a seal mechanism of the liquid fuel spray device in a front-back direction.
Fig. 9 is a view showing the change of a combustion and melting zone and a heat pattern in a test pot by liquid fuel spraying.
Fig. 10 includes views (photographs) showing the change in the combustion and melting zone in the test pot by liquid fuel spraying.
Fig. 11 includes schematic views showing a principle of liquid fuel spraying of the present invention, (a) is a view showing the state of a pot test, (b) is a view schematically illustrating a phenomenon of the pot test, (c) is a view showing a point of combustion, and (d) is a view showing an intralayer temperature.
Fig. 12 is a view showing a combustion state in liquid fuel spraying of the present invention.
Fig. 13 is a view showing an ignition state in liquid fuel spraying of the present invention.
Fig. 14 is a cross-sectional view showing another embodiment of the present invention taken along the line A-A shown in Fig. 1.
Fig. 15 is a view illustrating a conventional sintering process.
Fig. 16 is a view illustrating a pressure loss and a temperature distribution in a sintering layer.
Fig. 17 is an explanation view of comparison in temperature distribution between high production and low production.
Fig. 18 includes views showing a temperature distribution and a yield distribution in a sintering machine, (a) shows a proceeding process of sintering, (b) shows the temperature distribution, and (c) shows the yield distribution.

Reference Numerals

[0033]

1 raw material hopper; 2 drum mixer; 3 rotary kiln; 4 surge hopper; 5 hearth hopper; 6 drum feeder; 7 charge chute; 8 sintering machine pallet; 9 sintering bed; 10 ignition furnace; 11 wind box; 15 liquid fuel spray device; 16 hood; 21 compressed air supply pipe; 22 liquid fuel supply pipe; 23 spray mechanism; 24 vertical pipe; 25 mixing portion; 26 communicating pipe; 27 branch spray portion; 28a, 28b spray nozzle portion; 29 liquid fuel mist; 31 compressed gas supply main pipe; 32 compressed gas supply source; 33 gas storage tank; 34 compressor; 35 receiver tank; 36 liquid fuel supply main pipe; 37 fuel supply pump; 38 liquid fuel storage tank; 41 wipre seal; 51 baffle plate; 52 baffle plate line

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0034] A method for producing a sintered ore using a sintering machine, according to the present invention, includes a charging step, an ignition step, a liquid fuel supply step, and a sintering step. In this producing method, the charging step comprises charging a sintering raw material containing a fine ore and a carbonaceous material onto a circular traveling pallet to form a sintering bed of the sintering raw material thereon, and the ignition step comprises igniting a carbonaceous material on a surface of the sintering bed using an ignition furnace. In addition, the liquid fuel supply step comprises supplying a liquid fuel atomized to 100 μm or less to an upper portion of the sintering bed, and the sintering step is a step in which the atomize liquid fuel is sucked together with air into the sintering bed by a suction force of wind boxes disposed below the pallet and is combusted in the sintering bed, and at the same time, the carbonaceous material in the sintering bed is combusted by air sucked thereinto, so that by heat generated by these combustions, the sintering raw material is sintered to generate a sintered cake.

[0035] In the present invention, when the atomized liquid fuel is sprayed at a downstream side of the ignition furnace to the air at an upper portion of the sintering bed as described above, the atomized liquid fuel can be vaporized in the sintering bed by air suction by the wind boxes while ignition or the like is suppressed.

[0036] Fig. 1 is a schematic structural view showing one embodiment of a sintering machine of the present invention. In this Fig. 1, as in the case of the conventional example described above, sintering raw materials, such as a fine iron ore, recovered fine in steel works, under-sieve fine of a sintered ore, a CaO-containing auxiliary raw material such as limestone and dolomite, an agglomeration assistant such as burnt lime, coke fine, and anthracite are supplied from a plurality of hoppers 1 on a conveyor at a predetermined ratio, and the supplied raw materials are blended together and agglomerated in a drum mixer 2, a rotary kiln 3, and the like with the addition of an adequate amount of water, so that a sintering raw material which is quasi-particles having an average particle size in.a range of 3.0 and 6.0 mm is formed and is stored in a surge hopper 5 as a sintering raw material. In addition, a particle-size regulated lump ore having a predetermined particle size is supplied from a hearth hopper 4 to form a hearth layer on a grate of a sintering machine pallet 8.

[0037] Next, the sintering raw material is charged onto the hearth layer on the endless traveling sintering machine pallet 8 from the surge hopper 5 through a drum feeder 6 and a charge chute 7, thereby forming a sintering bed 9 which is also called a sintering bed. The thickness (height) of the sintering bed is generally in a range of approximately 400 to 800 mm. Then, a carbonaceous material in a surface layer of this sintering bed 9 is ignited by an ignition furnace 10 positioned above the sintering bed 9, and at the same time, downward air suction is performed using wind boxes 11 located below the pallet 8, so that the carbonaceous material in the sintering bed is successively combusted.

[0038] In addition, at a downstream side of the ignition furnace 10, a liquid fuel spray device 15 is provided which atomizes a liquid fuel and then sprays it at .an upper side of the sintering bed 9 in an approximately horizontal direction.

[0039] At least one liquid fuel spray device 15 is disposed at a position located at a downstream side of the ignition furnace 10 in a pallet travelling direction which is a direction in a process in which a combustion and melting zone moves in the sintering bed 9, and the supply of a liquid fuel mist into the sintering bed 9 is preferably performed at a position after the carbonaceous material in the sintering bed 9 is ignited. At least one liquid fuel spray device 15 is provided at an arbitrary position which is a downstream side of the ignition furnace 10 and which is a position at which a combustion front already propagates below the surface layer, and in order to control the cold strength of a targeted product sintered ore, the size, the position, and the number of devices are determined as described below.

[0040] As shown in Fig. 2, this liquid fuel spray device 15 has a hood 16 covering an upper portion of the sintering machine pallet 8, and an opening 17 having a relatively large area is provided in an upper portion of this hood 16.

[0041] As shown in Figs. 2 and 4, in this hood 16, plural sets, such as 9 sets, each composed of a compressed air supply pipe 21 and a liquid fuel supply pipe 22, which are along a traveling direction of the sintering machine pallet 8, are provided above the sintering bed 9 with predetermined intervals in a width direction perpendicular to the traveling direction of the sintering machine pallet 8. At a lower surface side of each compressed air supply pipe 21 and each liquid fuel supply pipe 22, spray mechanisms 23 are provided with predetermined intervals in the traveling direction of the sintering machine pallet 8. These spray mechanisms 23 are disposed in a staggered manner along the traveling direction of the sintering machine pallet 8 so that adjacent spray mechanisms 23 in the width direction of the sintering machine pallet 8 do not face each other. In addition, the number of sets each containing the compressed air supply pipe 21 and the liquid fuel supply pipe 22 is not limited to 9 sets, and a plurality of sets, such as 3 to 15 sets, is preferably provided.

[0042] As shown by an enlarged view of Fig. 3, the spray mechanism 23 is formed of a vertical pipe 24 connected to a lower surface of a compressed gas supply pipe 21, a mixing portion 25 formed at a middle portion of this vertical pipe 24, a connecting pipe 26 connecting between a lower surface of the liquid fuel supply pipe 22 and this mixing portion 25, and a branch spray portion 27 provided at a lower end of the vertical pipe 24 and branched to have two branches in the width direction of the sintering machine pallet 8.

[0043] The branch spray portion 27 has two spray nozzle portions 28a and 28b symmetrically provided with the vertical pipe 24 interposed therebetween. From each of these spray nozzle portions 28a and 28b, for example, a liquid fuel mist

29 atomized in the form of fine particles having a size of 100 μm or less is sprayed in an approximately horizontal direction.

[0044] The reason the particle size of the liquid fuel mist 29 is set to 100 μm or less is that when the particle size is more than 100 μm, since a part thereof remains in a surface layer portion of the sintering bed 9 and starts to be combusted at the surface layer portion, a holding time in a high-temperature region in an upper layer and a middle layer portion of the sintering bed 9, in which insufficient combustion occurs, is not increased, and the liquid fuel mist 29 is wastefully consumed. In addition, although a smaller particle size of the liquid fuel mist 29 is more preferable, the generation amount thereof is decreased as the particle size is decreased, and hence the particle size of the liquid fuel mist 29 is preferably selected in a range of 20 to 50 μm. When the particle size of the liquid fuel mist 29 is 50 μm or less, while the combustion above the sintering bed 9 and at the surface layer portion thereof is suppressed, the mist 29 passes through crack portions in a sintered cake formed in the surface layer to reach the combustion and melting zone, or after being once vaporized in the sintered cake, the mist 29 passes therethrough in the form of gas to reach the combustion and melting zone, so that the combustion occurs. In addition, when the particle size is less than 20 μm, the generation amount of the liquid fuel mist 29 is decreased, and as a result, a preferable effect of increasing the holding time in a high-temperature region obtained by introduction of the liquid fuel mist 29 into the sintering bed 9 cannot be obtained.

[0045] A central line of each of the spray nozzle portions 28a and 28b has a front-descending slope which gradually descends from the vertical pipe 24 toward the front end and is set, for example, to have an open angle of approximately 85° with respect to the central axis of the vertical pipe 24. Since the spray nozzle.portions 28a and 29a each have a slightly front-descending slope, when the spray of the liquid fuel mist is completed, no liquid fuel mist remains in the form of a liquid in each of the spray nozzle portions 28a and 28b, and the mist is all dripped out therefrom. The open angle described above is preferably in a range of 20° to 90°. The angle is more preferably in a range of 45° to 85°.

[0046] As described above, since the spray mechanisms 23 are disposed in a staggered manner in the traveling direction of the sintering machine pallet 8, as shown in Fig. 5, the liquid fuel mists 29 sprayed from the spray nozzle portions 28a and 28b of each spray mechanism 23 do not interfere with' each other and are uniformly sprayed and dispersed on the sintering bed 9. Subsequently, by using a suction force of the wind boxes not shown provided below the sintering machine pallet 8, the liquid fuel mist 29 is introduced into a deep portion (lower layer) of the sintering bed through the sintered cake generated in the surface layer of the sintering bed 9.

[0047] As shown in detail in Fig. 6, each compressed gas supply pipe 21 is connected to a compressed gas supply main pipe 31 through a flow meter FC at an upstream side of the sintering machine pallet 8 and further through a control valve VC, and this compressed gas supply main pipe 31 is connected to a compressed gas supply source 32. This compressed gas supply source 32 has a storage tank 33 which stores a gas using any one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component, and the gas stored in this storage tank 33 is compressed into a compressed gas by a compressor 34, is stored in a receiver tank 35, and is then supplied therefrom to each control valve VC through the compressed gas supply main pipe 31. In this case, between the receiver tank 35 and each flow meter FC, there are provided a main flow path LM in which the control valve VC is inserted and a bypass flow path LB which supplies a relatively small amount of compressed air and which bypasses the control valve VC. In the state in which the liquid fuel mist 29 is not sprayed from the spray mechanism 23, a small amount of the compressed gas is supplied from the receiver tank 35 to the spray mechanism 23 through the bypass flow path LB and the flow meter FC, so that this bypass flow path LB prevents the spray nozzle portions 28a and 28b of the spray mechanism 23 from being clogged.

[0048] Each liquid fuel supply pipe 22 is also connected to a liquid fuel supply main pipe 36 through a flow meter FF at an upstream side of the sintering machine pallet 8 and further through a control valve VF, and this liquid fuel supply main pipe 36 is connected to a liquid fuel storage tank 38 functioning as a liquid fuel supply source through a fuel supply pump 37. In this case, the liquid fuel supply pipes 22 and the liquid fuel supply main pipe 36 are each preferably obliquely disposed to have a front-descending slope in which the placement height at a downstream side is low as compared to that at an upstream side so that when the spray of the liquid fuel mist 29 is completed, no liquid fuel remains in the liquid fuel supply pipes 22 and the liquid fuel supply main pipe 36.

[0049] As the liquid fuel, at least one of a petroleum-based liquid fuel, such as lamp oil, light oil, or heavy oil, an alcohol-based liquid fuel, such as ethyl alcohol or methyl alcohol, an ether-based liquid fuel, and another hydrocarbon -based liquid fuel, each of which is liquid at ordinary temperature, is used and is stored in the liquid fuel storage tank 38.

[0050] Liquid fuels which can be used in the present invention and the properties thereof are shown in the following Table 1.

[TABLE 1]

MATERIAL NAME (LIQUID FUEL)	SPECIFIC GRAVITY (15°C)	BOILING POINT (°C)	COMBUSTION LIMIT (vol%)		IGNITION TEMPERATURE (IGNITION POINT) (°C)
			LOWER LIMIT	UPPER LIMIT	
PENTANE	0.631	36.0	1.5	7.8	284
HEXANE	0.664	68.7	1.2	7.4	260
HEPTANE	0.688	98.4	1.2	6.7	247
OCTANE	0.707	125.0	1.0	-	240
NONANE	0.722	150.0	0.8	2.9	234
DECANE	0.734	174	0.8	5.4	231
BENZENE	0.885	80.1	1.3	7.9	592
ACETONE	0.792	56.6	2.6	13	561
METHYL ALCOHOL	0.793	64.4	6.7	36	470
ETHYL ALCOHOL	0.789	78.3	3.3	19	392
DIETHYL ETHER	0.714	34.4	1.9	48	185
LAMP OIL (KEROSENE)	0.8~0.85	160~320	1.1	6.0	255
LIGHT OIL (DIESEL OIL)	0.83~0.88	250~350	1.0	6.0	250
HEAVY OIL	0.86	302~	1.0	7.0	240

[0051] Since having a high ignition point as compared to that of any one of a blast furnace gas, a coke oven gas, a blast furnace/coke oven mixed gas, a city gas, a natural gas, a methane gas, an ethane gas, a propane gas, a butane gas, and a mixed gas thereof, the liquid fuel mist 29 which is formed by atomizing the liquid fuel mentioned above and which is to be sprayed is combusted more inside the sintering bed 9 at which the temperature is higher than that of the surface layer of the sintering bed 9, that is, the sintering bed, and hence, the temperature of a skirt of the combustion and melting zone at an spraying position can be effectively increased. A liquid fuel having an ignition point in a range of 180°C to 500°C is preferable.

[0052] In addition, it is preferably designed so that a relatively large amount of the liquid fuel mist 29 is to be supplied to locations of low yield portions in the vicinities of right and left sidewalls 18 of the hood 16.

[0053] Since containing a component which is easily to be ignited and/or a component which has a low ignition point in some cases, waste oil and the like are not preferably used in the present invention. The reason for this is that when a liquid fuel, such as waste oil, containing a component having a low ignition point or flash point is vaporized beforehand and is then supplied on the sintering bed 9, that is, on the sintering raw material bed, combustion occurs in a space above the surface layer of the sintering bed 9 or in the vicinity of the surface layer thereof before the above liquid fuel reaches the vicinity of the combustion zone in the sintering bed 9, and an effect of increasing the holding time in a high-temperature region, such as a region of 1,200°C or more, by combustion performed in the vicinity of the combustion zone in the sintering bed 9, which is the intension of the present invention, cannot be obtained.

[0054] The reason the holding time in a liquid high-temperature region can be increased as described above when the liquid fuel mist 29 is sprayed above the sintering bed 9 is as follows. An experimental apparatus shown in Fig. 9, that is, a vertical tubular test pot provided with a transparent quartz window (diameter: 150 mm, height: 400 mm), is prepared; sesame oil is used as a liquid fuel to be used; a sintering bed is formed from the same sintering raw materials as those used in a sintering work of the present applicant, that is, the sintering bed is formed from sintering raw materials shown in the following Table 2; the height of an spraying nozzle spraying sesame oil is set to 320 mm from the surface of the sintering bed; and a coke fine ratio, an ignition time, a suction thickness, an spraying amount, and an spraying position are set, respectively, to 5.0% (base value: 5.25%) on an equivalent caloric value basis, 30 seconds, 1,200 mm H_2O, 5.0 ml/min, and a portion at one half of an upper layer 30 seconds after the ignition. In addition, an spraying time is set in a range of 1 to 6 minutes after the ignition. As the properties of the sesame oil used as the liquid fuel, the flash point is 255°C, the calorific value is 40.3 kJ/g, and the density is 0.92 g/cm^3.

[Table 2]

TYPE OF RAW MATERIAL	FRACTION (mass%)
ROBE RIVER	9.6
YANDI	23.8
CARAJAS	42.6
LIMESTONE	16.6
SILICA STONE	2.7
COKE FINE	4.7

[0055] As shown in Fig. 9, according to the test results of this liquid fuel spraying, under the (base) condition in which no liquid fuel is sprayed, the width of the combustion zone 5 minutes after the ignition is 65 mm, and the temperature of a heat pattern at a position 50 mm below the surface of the sintering bed is rapidly increased 1 minute after the ignition to more than 1,200°C and is then to be decreased after a temperature of more than 1,200°C is maintained for 33 seconds.

[0056] On the other hand, when sesame oil is sprayed for 1 to 6 minutes after the ignition, the width of the combustion zone 5 minutes after the ignition is increased to 114 mm, and in addition, the temperature of a heat pattern at a position 50 mm below the surface of the sintering bed is rapidly increased 1 minute after the ignition to more than 1,200°C, and after a temperature of more than 1,200°C is maintained for 82 seconds, the temperature is decreased at a relatively slow rate.

[0057] Accordingly, when sesame oil is sprayed, the width of the combustion zone is not only increased, but also the holding time of a heat pattern at a temperature of more than 1,200°C, that is, the holding time in a high-temperature region, can be increased to 82 seconds, and compared to the case in which no liquid fuel is sprayed, the width of the combustion zone and the holding time in a high-temperature region can be increased by approximately 1.75 times and approximately 2.5 times, respectively.

[0058] In addition, by using an experimental apparatus similar to that described above under spraying conditions similar to those described above, when the combustion zones were compared to each other among three cases of no liquid fuel spraying, spraying of sesame oil, and spraying of heavy oil, compared to the case of no liquid fuel spraying, as shown in Fig. 10, the width of the combustion zone could be increased by the spraying of sesame oil, and by the spraying of heavy oil, the width of the combustion zone could be further increased. The properties of individual liquid fuels are as shown in Table 3, the calorific value (kJ/g) of each of colza oil and sesame oil is assumed equal to that of soybean oil, and the density (g/cm^3) of colza oil is assumed equal to that of soybean oil. Although the results obtained using these colza oil and soybean oil are not shown, the increase in width of the combustion zone and the increase in holding time in a high-temperature region, which were similar to those obtained by using sesame oil, were confirmed, and also the increase in width of the combustion zone and the increase in holding time in a high-temperature region, which were similar to those obtained by using heavy oil, were also confirmed by using lamp oil.

[Table 3]

	COLZA OIL	SOYBEA N OIL	SESAME OIL	HEAVY OIL	LAMP OIL
FLASH POINT (°C)	313~320	282	255	79	44
VISCOSITY (Pa·s)	-	0.051	-	0.060	0.030
CALORIFIC VALUE (kJ/g)	40.3	40.3	40.3	45.3	46.4
DENSITY (g/cm^3)	0.92	0.92	0.92	0.86	0.79

[0059] In addition, in the above embodiment, although the case in which, by using the spray mechanism 23 which sprays the liquid fuel mist 29, the atomized liquid fuel is formed by mixing a liquid fuel and a compressed gas in the mixing portion 25 and is sprayed above the sintering bed 9 in a horizontal direction is described, the present invention is not limited thereto, and a liquid fuel mist obtained by mixing a compressed gas and a liquid fuel supplied from the compressed gas supply source 32 and the fuel supply pump 37, respectively, using a mixing machine may be supplied to the branch spray portion 27 of each spray mechanism 23 through a mist supply pipe. In this case, in order to prevent the liquid fuel mist from being liquefied again, the temperature of the liquid fuel is preferably maintained at a temperature between the boiling point and less than the ignition point thereof.

[0060] In addition, in the present invention, as described above, the hood 16 which covers an upper portion of the sintering machine pallet 8 is provided. It is intended, by this hood 16, to reduce the influence on the concentration distribution of the liquid fuel mist 29 generated by a cross wind. That is, the present inventors found through various researches that the installation of the hood 16 as a measure against a cross wind is much effective than the installation of a partition. However, as described above, as the hood 16, a hood having an opening 17 at an upper central portion or an appropriate permeability (void ratio) is used so that air can be taken into the hood through the above portion.

[0061] Accordingly, inside the hood 16, the liquid fuel mist 29 sprayed from the spray mechanism 23 is mixed with air. In the case in which the sintering machine pallet 8 of the sintering machine has a width of 5 m, when the size of the opening 17 described above is set to approximately 1 m, the pressure loss of the hood 16 can be almost ignored. In addition, when voids are provided for the opening 17, it was found that if the permeability is set to approximately 80%, the pressure loss can be suppressed to approximately several mm Aq. Furthermore, it was also found from analytical results that when a rectifier plate 40 is provided in the hood 16, an effect of suppressing a vortex flow in the hood 16 can be obtained and that a most effective void ratio of a partition provided at an upper portion (periphery) of the hood 16 is in a range of 30% to 40%. In addition, as shown in Fig. 7, it is preferable that at an upper end of each of the right and left sidewalls 18 of the hood 16 provided along the traveling direction of the sintering machine pallet 8, a cross-wind depressing fence 16c formed, for example, of a punch metal having a permeability of approximately 30% is provided.

[0062] In addition, a space is inevitably formed between a lower side of the hood 16 and the surface of the sintering bed (the surface of the sintering bed), and if this space portion is not sufficiently sealed, for example, when the permeability is 20% to 30%, it was found that air is sucked into the hood 16 through this portion, and the deviation of the concentration distribution of the liquid fuel mist is increased. Hence, air coming into the hood 16 from a lower end thereof is preferably prevented.

[0063] Hence, between the lower ends of the right and left sidewalls 18 of the hood 16 provided along the traveling direction of the sintering machine pallet 8 and pallet sidewalls 8a and between lower surfaces of the branch spray portions 27 of the spray mechanisms 23 and the upper surface of the sintering bed 9, as schematically shown in Fig. 7, wipre seals 41, each of which is formed of wire brushes and a seal sheet provided therebetween, are provided, and at the outside thereof, covers 42 are provided so as to cover the wipre seals 41 from the outside. In addition, as the seal material, besides the wipre seal 41, a seal material, such as a chain curtain, a seal brush, or an adhesive seal, may be appropriately used. In addition, the above seal material preferably has heat resistance and flexibility or a high degree of freedom of deformation and also preferably does not hurt the surface of the sintering bed 9.

[0064] In addition, between the surface of the sintering bed 9 and a lower end of each of front and back plate portions 16b of the hood 16 located at an upstream side and a downstream side of the traveling direction of the sintering machine pallet 8, as shown in Fig. 8, an air path 43 is provided along each of front and back walls 19, and air is preferably sprayed from a lower side of this air path 43 to form an air curtain.

[0065] In addition, the installation position, the size, and the number of the liquid fuel spray devices 15 are determined as described below.

[0066] That is, after the carbonaceous material in the sintering bed 9 is ignited, the liquid fuel mist 29 is supplied (introduced) on the sintering bed 9. The reason for this is that even when being supplied at a position immediately after the ignition, the liquid fuel mist 29 is combusted only on the surface layer of the sintering bed 9 and has no influence on a combustion layer. Hence, after a sintering raw material at the upper portion of the sintering bed 9 is fired, and a sintering completion zone, which is a layer of a sintered cake, is formed, it is necessary to supply the liquid fuel mist 29 to the sintering bed 9.

[0067] The principle in the case of using the liquid fuel mist according to the present invention will be described with reference to Fig. 11. Fig. 11(a) is a photograph obtained when ethanol having a particle size of approximately 50 μm was used for a pot test. It is found that as ethanol is sprayed, the combustion and melting zone is remarkably increased. Fig. 11(b) is a view schematically illustrating this phenomenon, and a left side of the figure indicates a sintering reaction when a liquid fuel is sprayed. Coke fine functioning as a coagulating agent is ignited by an ignition furnace, and a combustion zone by the coke fine descends in a sintering bed of a sintering raw material, so that a sintering reaction proceeds downward. A sintering zone is formed in a sintering completion zone, a gas combustion zone of a liquid fuel gas is generated when a liquid fuel is sprayed between the sintering completion zone and a coke fine combustion zone, and at this point, the holding time in a high-temperature region is increased while the maximum temperature is not increased. A right side indicates a sintering reaction in the case of using the liquid fuel mist according to the present invention. The liquid fuel mist is gasified in the sintering completion zone, and hence, in the present invention, the particle size of the liquid fuel mist is set to 100 μm or less and preferably set to 50 μm or less as described above. When the particle size is more than 100 μm, liquid droplets may remain even when the heat of the sintering completion zone is used, and hence combustion may occur in the surface layer portion in some cases. When the particle size of the liquid fuel mist is set to 100 μm or less, since the liquid fuel mist (liquid fuel particles) and its agglomerated particles are gasified into a liquid fuel vapor, the gas combustion zone of the liquid fuel gas is generated when the liquid fuel is sprayed as the liquid fuel mist between the sintering completion zone and the coke fine combustion zone, and at this stage, the holding time in a high-temperature region is increased without increasing the maximum temperature, so that the same phenomenon as that obtained by using a gas fuel is obtained.

[0068] When the liquid fuel is sprayed, as shown in Fig. 11(b), a gasification (liquid fuel vapor) region of the liquid fuel particles is important.

[0069] That is, first, the liquid fuel is preferably sprayed from a spray nozzle so that the vapor concentration thereof in the gasification region of the liquid fuel shown in Fig. 11(b) is set to not more than the lower limit concentration of combustion shown in Table 1. When the liquid fuel is sprayed, the vapor concentration thereof is necessarily set to 75% or less of the lower limit concentration of combustion so as not to be combusted in the surface layer portion of the sintering completion zone, and the lower limit of the vapor concentration is set to 1% or more of the lower limit concentration of combustion in order to use fuel heat. The vapor concentration is preferably in a range of 4% to 25% of the lower limit concentration of combustion. The upper limit is determined in consideration of safety against a fire accident and the like, and the lower limit is determined by an effective heat quantity. In addition, the temperature must be equal to or less than the ignition point.

[0070] As shown in Fig. 11(c), the point of the combustion is that the maximum temperature in the sintering reaction is controlled at a coke fine side A, and that the holding time in a high-temperature region is controlled by the combustion at a liquid fuel side B in which the temperature of the combustion zone is maintained equal to or less than the maximum temperature. Fig. 11(d) shows its example. A temperature curve indicated by C is an intralayer temperature history in sintering producing by a sintering reaction when only coke fine is used as a coagulating agent. The maximum temperature is controlled by the amount of coke fine, and by this temperature pattern, a holding time E in a high-temperature region is determined. When the holding time in a high-temperature region is increased by this temperature pattern C, the addition amount of coke fine is necessarily increased so as to expand the skirt of a region at a temperature of 1,200°C or more, which is a high-temperature region; however, at the same time, the maximum temperature is necessarily increased. A temperature pattern obtained when a liquid fuel is used is shown by D. As shown in Fig. 11(d), the combustion of the liquid fuel is combustion at the liquid fuel side B shown in Fig. 11(c) in which the combustion zone temperature is maintained at the maximum temperature or less. By the combination between the above two, the temperature pattern D shown in Fig. 11(d) is obtained in which the temperature of the skirt region is increased without changing the maximum temperature. By this temperature pattern D, the skirt of a region of 1,200°C or more is expanded, and a holding time F in a high-temperature region can be ensured.

[0071] Fig. 12 are photographs of pot tests according to a conventional sintering method and a sintering method using a liquid fuel mist, and by the conventional sintering, since coke fine combustion heat is used, the coke fine ratio is high. In addition, the combustion and melting zone which looked white although the ratio was increased was only up to 65 mm in this experiment.

[0072] In the gasification region (sintering completion zone) of a liquid fuel in which the temperature is set equal to or more than the boiling point of the liquid fuel and is set equal to or less than the ignition point thereof (controllable by decreasing the concentration lower than the lower limit concentration of combustion), heavy oil and ethanol each used as the liquid fuel are shown by way of example; however, in order to control the maximum temperature at 1,380°C, the amount of coke fine was decreased. The combustion and melting zones, both of which looked white, were expanded, and a sintered ore strength thus obtained was higher than that obtained by a conventional sintering method which only used coke fine.

[0073] In addition, in the gasification region (sintering completion zone) of the liquid fuel shown in Fig. 11(b), the temperature of this region must be equal to or more than the boiling point of the liquid fuel and equal to or less than the ignition point thereof. Accordingly, the phenomenon shown in Fig. 12 can be observed.

[0074] In addition, when the temperature of the gasification region (sintering completion zone) is more than the ignition point (high concentration close to the lower limit concentration of combustion), as shown in Fig. 13, since the liquid fuel vapor is combusted on the surface of the sintering completion zone before entering the coke fine combustion zone, the effect cannot be obtained, and adverse influences, such as oxygen deficiency, may occur on the sintering operation.

[0075] When the layer of the sintered cake is formed on the surface of the sintering bed 9, the liquid fuel mist may be supplied at an arbitrary position until the sintering is completed. The other reasons the liquid fuel mist is supplied after the layer of the sintered cake is formed are as follows.

(a) When the liquid fuel mist is supplied immediately after the ignition at which the sintered cake is not generated in the upper portion of the sintering bed 9, combustion may starts on this sintering bed 9.

(b) The liquid fuel mist is preferably supplied at a portion at which the yield of the sintered ore must be increased, that is, the liquid fuel mist is preferably supplied to cause combustion at a portion at which the strength of the sintered ore is desirably increased.

[0076] In order to control at least one of a sintering bed maximum cylindrical temperature and the holding time in a high-temperature region, in the state in which the combustion and melting zone has a thickness of at least 15 mm or more, preferably 20 mm or more, and more preferably 30 mm or more, the liquid fuel mist is preferably supplied. The reason for this is that when the combustion and melting zone has a thickness of less than 15 mm, by an cooling effect caused by air and the liquid fuel mist sucked through a sintering layer (sintered cake), even if the liquid fuel mist is combusted, the effect thereof is not sufficient, and hence, the thickness of the combustion and melting zone cannot be increased. On the other hand, at the stage at which the thickness of the combustion and melting zone is 15 mm or more, preferably 20 mm or more, and more preferably 30 mm or more, when the liquid fuel mist is supplied, the thickness of the combustion and melting zone is significantly increased, and the holding time in a high-temperature region can be increased, so that a sintered ore having a high cold strength can be obtained.

[0077] In addition, the liquid fuel mist is preferably introduced into the sintering bed 9 at a position at which the combustion front descends below the surface layer, and the combustion and melting zone descends from the surface layer by 100 mm or more and more preferably 200 mm or more, that is, the liquid fuel mist is preferably supplied so as to pass through a sintered cake region (sintering layer) generated in the middle layer and the lower layer of the sintering bed 9 without combustion and so as to combust at the stage at which the combustion front moves from the surface layer by 100 mm or more. The reason for this is that when the combustion front is located at a position 100 mm or more below the surface layer, the adverse influence of cooling by air sucked through the sintering layer is reduced, and the thickness of the combustion and melting zone can be increased. Furthermore, when the combustion and melting zone is located at a position 200 mm or more below the surface layer, the influence of cooling by air can be almost eliminated, and the thickness of the combustion and melting zone can be increased to 30 mm or more. In addition, the liquid fuel mist is preferably supplied in the vicinities of the sidewalls at the two end portions in the pallet width direction at which the yield is considerably decreased.

[0078] Although depending on the size of a sintering machine, for example, when a sintering machine having a production volume of approximately 15,000 t/day and a machine length of 90 m is used, the liquid fuel spray device 15 is preferably installed at a position approximately 5 m apart from the ignition furnace 10 at a downstream side.

[0079] In the sintering machine of the present invention, the supply position of the liquid fuel mist (introduction position into the sintering bed) is preferably set at at least one arbitrary position located at an exit side of the ignition furnace in the pallet traveling direction and from a position at which after the sintered cake is generated, a so-called combustion front propagates below the surface layer (for example, a position 100 mm or more and preferably approximately 200 mm or less below the surface layer, and at which combustion of the liquid fuel mist occurs) to a position at which the sintering is completed. This indicates that as described above, the liquid fuel mist starts to be introduced at the stage at which the combustion front moves below the surface layer of the sintering bed, and as a result, since the liquid fuel mist is combusted in the sintering bed and gradually further moves downward, explosion hardly occurs, so that it indicates that safe sintering operation can be performed.

[0080] In the method for producing a sintered ore according to the present invention, the introduction of the liquid fuel mist into the sintering bed also indicates the promotion of re-heating of the generated sintered cake. That is, the supply of this liquid fuel mist is performed to supply a liquid fuel mist having a high reactivity compared to that of a solid fuel to a portion at which heat deficiency is intrinsically liable to occur due to a short holding time in a high-temperature region and the cold strength of a sintered ore is low, and hence, this supply is responsible to recover and expand the combustion and melting zone by compensation for combustion heat at the portion at which heat deficiency is liable to occur.

[0081] In addition, in the method for producing a sintered ore according to the present invention, after the ignition, the liquid fuel mist is preferably supplied from the upper portion of the sintering bed so that at least part of the liquid fuel mist introduced into the sintering bed reaches the combustion and melting zone in a non-combusted state and is combusted at a position at which the combustion heat is necessarily compensated for. The reason for this is believed that the supply of the liquid fuel mist, that is, the introduction effect thereof into the sintering bed, can be made more effective if this effect is applied not only to the upper portion of the sintering bed but also to the combustion and melting zone which is located at a central portion in the thickness direction. That is, when the liquid fuel mist is supplied at the upper layer portion of the sintering bed at which heat deficiency is liable to occur (insufficient holding time in a high-temperature region), sufficient combustion heat can be provided, and hence the quality of a sintered cake in this portion can be improved. Furthermore, when a supply operation of the liquid fuel mist is performed to a zone including the middle layer and the layer thereunder, since the same result can be obtained as that obtained when a re-combustion and melting zone is formed by a liquid fuel mist on the original combustion and melting zone formed by a carbonaceous material, the width of the combustion and melting zone can be increased in the top to bottom direction thereof; hence, without increasing the ultimate maximum temperature, the holding time in a high-temperature region can be increased, and thereby sufficient sintering can be realized without decreasing the traveling speed of the pallet. As a result, the quality of the sintered cake in the entire sintering bed can be improved (improvement in cold strength), and hence, the quality (cold strength) and the productivity of the product sintered ore can be improved.

[0082] In addition, in the present invention, when the liquid fuel mist is introduced (supplied) into the sintering bed, it is preferable that the supply position is not only controlled but the form of the combustion and melting zone itself is also controlled, and furthermore, the ultimate maximum temperature of the combustion and melting zone and/or the holding time in a high-temperature region are also preferably controlled.

[0083] In general, in the sintering bed after the ignition is performed, while the combustion (flame) front gradually expands downward and forward (downstream side) as the pallet travels, the position of the combustion and melting zone changes as shown in Fig. 18(a) described above. In addition, as shown in Fig. 18(b), the heat history caused by the sintering process in the sintering layer differs among the upper layer, the middle layer, and the lower layer, and from the upper layer to the lower layer, the holding time in a high-temperature region (time at a temperature of approximately 1,200°C or more) is significantly different. As a result, the yields of sintered ore at different places in the pallet have a distribution as shown in Fig. 18(c). That is, the yield at the surface layer portion (upper layer portion) is low, and the yield is high at the middle and the lower layer portions. Hence, when the above liquid fuel mist is supplied in accordance with the method of the present invention, for example, the thickness in the top to bottom direction and the width in the pallet travelling direction of the combustion and melting zone are increased, and this is reflected to the quality improvement of the product sintered ore. In addition, in the middle layer portion and the lower layer portion each having a high yield distribution, since the holding time in a high-temperature region can be further controlled, the yield can be further improved.

[0084] When the supply (introduction) position of the liquid fuel mist is controlled, the form of the combustion and melting zone, that is, the thickness thereof in the height direction and/or the width in the pallet traveling direction, can be controlled, and in addition, the ultimate maximum temperature and the holding time in a high-temperature region can also be controlled. These controls can more significantly enhance the effect of the present invention, and by the increase of the thickness of the combustion and melting zone in the top to bottom direction, the increase of the width thereof in the pallet traveling direction, and the control of the ultimate maximum temperature and the holding time in a high-temperature region, sufficient sintering can always be achieved, and the cold strength of the product sintered ore can be effectively improved thereby.

[0085] In addition, in the present invention, it may also be said that the supply (introduction) of the liquid fuel mist into the sintering bed is to control the cold strength of the entire product sintered ore. That is, the original purpose to supply the liquid fuel mist is to improve the cold strength of the sintered cake, that is, of the sintered ore, and in particular, by the supply position control of the liquid fuel mist, the control of the holding time in a high-temperature region which is a time in which the sintering raw material stays in the combustion and melting zone, and the control of the ultimate maximum temperature, the cold strength (shutter index SI) of the sintered ore is set in a range of approximately 75% to 85%, preferably 80% or more, and more preferably 90% or more.

[0086] In the present invention, the strength level described above can be achieved at low cost, in particular, when the concentration, supply amount, supply position, and supply range of the liquid fuel mist are preferably controlled in consideration of the amount of the carbonaceous material in the sintering raw material (under the condition in which the heat quantity to be supplied is constant). In addition, the improvement in cold strength of the sintered ore may cause an increase in gas flow resistance and a decrease in productivity; however, in the present invention, these problems are solved by also controlling the ultimate maximum temperature and the holding time in a high-temperature region, and in addition, the cold strength of the sintered ore can be improved. In addition, the cold strength SI index value of a sintered ore produced by an actual sintering machine is 10% to 15% higher than that obtained by the pot test.

[0087] In the producing method of the present invention, the introduction position of the liquid fuel mist into the sintering bed in the pallet traveling direction is determined depending on the level of the cold strength of the sintered ore in an arbitrary zone between the sintered cake generated in the sintering bed and the wet zone. For this control, in the present invention, by preferably controlling the size (scale), the number, the position (distance from the ignition furnace), and the gas concentration of the liquid fuel spray device in accordance with the amount of a carbonaceous material (solid fuel) in the sintering raw material, the size (the thickness in the top to bottom direction and the width in the pallet traveling direction) of the combustion and melting zone is not only primarily controlled but the ultimate high temperature and the holding time in a high-temperature region are also controlled, and thereby, the strength of the sintered cake generated in the sintering bed is controlled.

[0088] Next, the operation of the above embodiment will be described.

[0089] First, as shown in Fig. 1, a particle-size regulated lump ore is supplied from the hearth hopper 4 on the grate of the sintering machine pallet 8 to form a hearth layer, and a predetermined amount of a sintering raw material supplied from the surge hopper 5 through the drum feeder 6 is charged on this hearth layer to form the sintering bed 9, which is also called a sintering bed, having a thickness of approximately 400 to 800 mm.

[0090] In addition, as the sintering machine pallet 8 travels, the carbonaceous material in the surface layer of the sintering bed 9 which moves below the ignition furnace 10 is ignited.

[0091] In the sintering bed 9 thus ignited, as the sintering machine pallet 8 travels, the combustion (flame) front gradually propagates downward and forward (downstream side), and the position of the combustion and melting zone changes as shown in Fig. 18(a) described above. In addition, when the position of the combustion and melting zone changes from the upper layer to the middle layer, that is, when the position of the combustion and melting zone reaches a position approximately 200 mm from the surface layer, the sintering machine pallet 8 reaches the position of the liquid fuel spray device 15.

[0092] In this liquid fuel spray device 15, the liquid fuel mist 29 is uniformly sprayed on the surface of the sintering bed 9 by the spray mechanisms 23 provided in the hood 16 which covers the upper portion of the sintering machine pallet 8.

[0093] That is, in the liquid fuel spray device 15, a predetermined number of sets each containing a compressed gas supply pipe 22 and the liquid fuel supply pipe 22, which extend in parallel along the traveling direction of the sintering machine pallet 8, are provided at positions at a predetermined distance from the surface of the sintering bed 9 on the sintering machine pallet 8 in the width direction perpendicular to the traveling direction. In addition, the spray mechanisms 23 are provided at each set containing the compressed gas supply pipe 21 and the liquid fuel supply pipe 22, the spray mechanisms 23 each being designed to spray in an approximately horizontal direction an atomized liquid fuel mist having a particle size of 100 μm or less and preferably in a range of 20 to 50 μm which is obtained by mixing a compressed gas and a liquid fuel.

[0094] In addition, as shown in Fig. 5, spray mechanisms 23 of adjacent two sets are disposed at positions each shifted by a half pitch in the traveling direction of the sintering pallet 8 so as not to face each other between the adjacent two sets, and hence liquid fuel mists 29 sprayed from the spray nozzle portions 28a and 28b of the spray mechanisms 23 of the adjacent two sets each form a uniform spray region without causing any interference therebetween.

[0095] The liquid fuel mist 29 thus sprayed is diluted by mixing with air which is rectified by the rectifier plate 40 to not more than the lower limit concentration of combustion at ordinary temperature, and hence the combustion above the sintering bed 9 can be suppressed. In this case, as an atomizing gas for atomizing the liquid fuel, a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component is used, and since at least one of these flame extinguishing compressed gases is contained in the liquid fuel mist 29, the combustion of the liquid fuel mist 29 above the sintering bed 9 can be reliably suppressed.

[0096] Subsequently, when air is sucked downward through the wind boxes 11 provided at the lower side of the sintering machine pallet 8, the liquid fuel mist 29 sprayed from the spray nozzle portions 28a and 28b of each spray mechanism 23 is mixed with air rectified by the rectifier plate 40 and is then introduced into the sintering bed 9.

[0097] After passing through the sintered cake generated in the surface layer portion, the liquid fuel mist 29 introduced into the sintering bed 9 reaches the combustion and melting zone located at a position 100 mm or more below the surface and is combusted in this combustion and melting layer. Hence, in the upper and middle layer regions in which heat deficiency is intrinsically liable to occur due to a short holding time in a high-temperature region and in which the cold strength of a sintered ore is low, the holding time in a high-temperature region of 1,200°C or more can be increased, and hence the cold strength of a sintered ore can be improved. Accordingly, the yield of the upper and the middle layer portions shown in Fig. 18(c) in which the yield is low when the liquid fuel mist 29 is not sprayed can be improved.

[0098] As described above, when the supply operation of the liquid fuel mist 29 is performed to a region including the middle layer portion and a portion thereunder, since the same result can be obtained as that obtained when a re-combustion and melting zone by the liquid fuel mist 29 is formed on the original combustion and melting zone formed by a carbonaceous material, the width of the combustion and melting zone can be increased in the top to bottom direction, and hence the holding time in a high-temperature region can be increased without increasing the ultimate maximum temperature, so that sufficient sintering can be realized without decreasing the traveling speed of the sintering machine pallet 8. As a result, the quality improvement (improvement in cold strength) of the sintered cake of the entire sintering bed 9 is obtained, and hence, the quality (cold strength) and the productivity of the sintered ore can be improved.

[0099] In addition, when the supply of the liquid fuel to a liquid fuel supply pipe 21 is started, and when the supply of the liquid fuel is stopped, it is preferable that a heated gas is supplied as a purge gas into the liquid fuel supply pipe 21 to remove a liquid fuel remaining therein by combustion.

[0100] As described above, in the above embodiment, after the surface layer of the sintering bed 9 is ignited by the ignition furnace 10, the liquid fuel mist 29 is sprayed at the upper side of the sintering machine pallet 8 by the liquid fuel spray device 15 so as to be uniformly dispersed. Hence, compared to the case of using a diluted gas fuel obtained by diluting a gas fuel, such as a propane gas, an LNG, or an M gas, with air, since a liquid fuel having a high ignition point is used, and instead of using this liquid fuel itself, the liquid fuel is atomized by a compressed gas and is then sprayed in the form of a liquid fuel mist, the probability of ignition at the upper side of the sintering bed 9 can be reliably suppressed. Furthermore, as the compressed gas, since a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component is used, the probability of ignition at the upper side of the sintering bed 9 can be further suppressed.

[0101] In addition, in the above embodiment, although the case in which the liquid fuel supply device 15 is disposed at a downstream side of the ignition furnace 10 is described, the present invention is not limited thereto, and when a thermal insulating furnace is disposed at a downstream side of the ignition furnace 10, the liquid fuel spray device 15 may be disposed at a downstream side of this thermal insulating furnace.

[0102] In addition, in the above embodiment, although the case in which the hood 16 of the liquid fuel supply device 15 is formed to have the opening 17 in an upper portion is described, the present invention is not limited thereto, and as shown in Fig. 14, the structure may be formed such that the hood 16 is formed to have an open upper end; three layers of baffle plate lines 52 are disposed in the top to bottom direction, each layer including a predetermined number of the baffle plate lines 52 disposed in the width direction perpendicular to the traveling direction of the sintering machine pallet 8 with predetermined intervals therebetween, each baffle plate line 52 being extended between the front and the back walls 19 of a hood 17 along the traveling direction of the sintering machine pallet 8 and including baffle plates 51 each having a dog-leg shaped cross-section in which the vertex thereof is located at an upper side; between adjacent two layers of the baffle plate lines 52 in the top to bottom direction, the baffle plates 51 of the baffle plate lines 52 of one layer are located between the baffle plates 51 of the baffle plate lines 52 of the other layer; and the spray mechanisms 23 are disposed at a lower side between the baffle plates 51 of the bottommost baffle plate lines 52.

[0103] Furthermore, in the above embodiment, although the case in which the liquid fuel is supplied from the liquid fuel tank 38 to the liquid fuel supply main pipe 36 and the liquid fuel supply pipes 22 at ordinary temperature is described, the present invention is not limited thereto. For example, as for a liquid fuel, such as C heavy oil, which has a high viscosity at ordinary temperature and which is difficult to be atomized, when pre-heating is performed using steam or the like to a temperature, for example, of 130°C to 150°C to decrease the viscosity of the liquid fuel, and the liquid fuel is supplied to the liquid fuel supply pipe 22, the liquid fuel can be easily atomized by the spray mechanism 23 and can be sprayed as the liquid fuel mist 29.

Industrial Applicability

[0104] The technique of the present invention is effective as a technique for producing a sintered ore used as an iron-making raw material, and in particular, as a blast-furnace raw material and can also be used as another ore agglomeration technique.

Claims

1. A method for producing a sintered ore comprising:

a charging step of charging a sintering raw material containing a fine ore and a carbonaceous material onto a circular traveling pallet (8) to form a sintering bed (9);
an ignition step of igniting the carbonaceous material in the sintering bed by an ignition furnace (10);
a liquid fuel supply step of supplying an atomized liquid fuel having a particle size of 100 μm or less above the sintering bed (9) after the ignition; and
a sintering step of sucking air through a wind box (11) disposed below the pallet (8) to produce the sintered ore.

2. The method for producing a sintered ore according to Claim 1, wherein the atomized liquid fuel has a particle size of 20 to 50 μm.

3. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises:

supplying an atomized liquid fuel having a particle size of 100 μm or less on the sintering bed (9); and
supplying the atomized liquid fuel into the sintering bed (9) in a condition that the atomized liquid fuel is diluted to not more than a lower limit concentration of combustion at ordinary temperature.

4. The method for producing a sintered ore according to Claim 1, wherein the atomized liquid fuel has a concentration of not more than a lower limit concentration of combustion.

5. The method for producing a sintered ore according to Claim 4, wherein the concentration is in a range of 1% to 75% of the lower limit concentration of combustion.

6. The method for producing a sintered ore according to Claim 5, wherein the concentration is in a range of 4% to 25% of the lower limit concentration of combustion.

7. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises spraying a atomized liquid fuel having a particle size of 100 μm or less in a horizontal direction at an upper side of the sintering bed (9).

8. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises:

mixing a liquid fuel and a compressed gas to form an atomized liquid fuel; and spraying the atomized liquid fuel above the sintering bed (9).

9. The method for producing a sintered ore according to Claim 8, wherein the compressed gas is a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component.

10. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel is at least one selected from the group consisting of a petroleum-based liquid fuel, an alcohol-based liquid fuel, an ether-based liquid fuel, and another hydrocarbon-based liquid fuel.

11. The method for producing a sintered ore according to Claim 10, wherein the petroleum-based liquid fuel is at least one selected from the group consisting of lamp oil, light oil, and heavy oil.

12. The method for producing a sintered ore according to Claim 10, wherein the alcohol-based liquid fuel is at least one selected from the group consisting of methyl alcohol, ethyl alcohol, and diethyl alcohol.

13. The method for producing a sintered ore according to Claim 10, wherein the another hydrocarbon-based liquid fuel is at least one selected from the group consisting of pentane, hexane, heptane, octane, nonane, decane, benzene, and acetone.

14. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises supplying an atomized liquid fuel from a formation of a sintered cake in a surface layer portion of the sintering bed (9) to a completion of sintering.

15. The method for producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises supplying an atomized liquid fuel in a region in which the thickness of a combustion and melting zone is 15 mm or more.

16. The method tor producing a sintered ore according to Claim 1, wherein the liquid fuel supply step comprises supplying an atomized liquid fuel after a combustion front reaches a position located 100 mm below a surface layer.

17. A sintering machine comprising:

a circular traveling pallet (8);
a raw material supply device (5, 6, 7) for charging a sintering raw material containing a fine ore and a carbonaceous material on the pallet (8) to form a sintering bed (9);
an ignition furnace (10) for igniting the carbonaceous material in the sintering raw material on the pallet;
a liquid fuel spray device (15) which is provided at a downstream side of the ignition furnace and which atomizes a liquid fuel to have a particle size of 100 μm or less and sprays the atomized liquid fuel on the sintering bed; and
a wind box (11) for sucking air to a lower side of the pallet,
wherein the liquid fuel spray device (15) comprises: a compressed gas supply source (21), a liquid fuel supply source (22), and a spray mechanism (23) which mixes a liquid fuel from the liquid fuel supply source (22) and a compressive gas from the compressive gas supply source (21) to form an atomized liquid fuel and which sprays the atomized liquid fuel above the sintering bed (9) in a horizontal direction.

18. The sintering machine according to Claim 17, wherein the spray mechanism (23) comprises: a transport pipe (24) which transports a mixed fluid of the compressed gas and the liquid fuel and which has a downward slope toward a downstream side; a communicating pipe (26) communicating with a lower surface side of the transport pipe; and a spray nozzle (28a, 28b) which is formed at a lower surface of the communicating pipe (26), sprays the liquid fuel in a horizontal direction, and has a downward slope toward an ejection port.

19. The sintering machine according to Claim 17, wherein the liquid fuel is at least one selected from the group consisting of a petroleum-based liquid fuel, an alcohol-based liquid fuel, an ether-based liquid fuel, and another hydrocarbon-based liquid fuel, each of which is in a liquid state at approximately ordinary temperature.

20. The sintering machine according to Claim 17, wherein the compressed gas is a gas containing at least one of flame extinguishing nitrogen, carbon dioxide, and water vapor as a primary component.

21. The sintering machine according to Claim 17, wherein the liquid fuel spray device (15) comprises a pre-heating mechanism for heating the liquid fuel so that the liquid fuel has an optimal viscosity for atomization thereof when having a high viscosity.

Patentansprüche

1. Verfahren zum Herstellen eines gesinterten Erzes, aufweisend:

   einen Beschickungsschritt des Beschickens eines Sinterrohmaterials, das ein Feinerz und ein kohlenstoffhaltiges Material enthält, auf eine sich bewegende Palette (8), um ein Sinterbett (9) auszubilden;
   einen Zündschritt des Zündens des kohlenstoffhaltigen Materials in dem Sinterbett durch einen Zündofen (10);
   einen Flüssigbrennstoffzufuhrschritt des Zuführens eines zerstäubten Flüssigbrennstoffs mit einer Partikelgröße von 100 μm oder weniger über dem Sinterbett (9) nach der Zündung; und
   einen Sinterschritt des Saugens von Luft durch eine Windbox (11), die unterhalb der Palette (8) angeordnet ist, um das gesinterte Erz zu erzeugen.

2. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der zerstäubte Flüssigbrennstoff eine Teilchengröße von 20 bis 50 μm aufweist.

3. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt aufweist:

   Zuführen eines zerstäubten Flüssigbrennstoffs mit einer Partikelgröße von 100 μm oder weniger auf dem Sinterbett (9); und
   Zuführen des zerstäubten Flüssigbrennstoffs in das Sinterbett (9) in einem Zustand, in dem der zerstäubte Flüssigbrennstoff auf nicht mehr als eine untere Grenzkonzentration der Verbrennung bei gewöhnlicher Temperatur verdünnt ist.

4. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der zerstäubte Flüssigbrennstoff eine Konzentration von nicht mehr als einer unteren Grenzkonzentration der Verbrennung aufweist.

5. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 4, wobei die Konzentration in einem Bereich von 1% bis 75% der unteren Grenzkonzentration der Verbrennung liegt.

6. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 5, wobei die Konzentration in einem Bereich von 4% bis 25% der unteren Grenzkonzentration der Verbrennung liegt.

7. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt das Sprühen eines zerstäubten Flüssigbrennstoffs mit einer Partikelgröße von 100 μm oder weniger in einer horizontalen Richtung an einer Oberseite des Sinterbetts (9) umfasst.

8. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt aufweist:

   Mischen eines Flüssigbrennstoffs und eines komprimierten Gases, um einen zerstäubten Flüssigbrennstoff auszubilden; und
   Sprühen des zerstäubten Flüssigbrennstoffs über das Sinterbett (9).

9. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 8, wobei das komprimierte Gas ein Gas ist, das mindestens eines aus flammenauslöschendem Stickstoff, Kohlendioxid und Wasserdampf als eine primäre Komponente enthält.

10. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoff mindestens einer ist, ausgewählt aus der Gruppe bestehend aus einem Flüssigbrennstoff auf Erdölbasis, einem Flüssigbrennstoff auf Alkoholbasis, einem Flüssigbrennstoff auf Etherbasis und einem anderen Flüssigbrennstoff auf Kohlenwasserstoffbasis.

11. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 10, wobei der Flüssigbrennstoff auf Erdölbasis mindestens einer ist, ausgewählt aus der Gruppe bestehend aus Lampenöl, Leichtöl und Schweröl.

12. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 10, wobei der auf Flüssigbrennstoff auf Alkoholbasis wenigstens einer ist, ausgewählt aus der Gruppe bestehend aus Methylalkohol, Ethylalkohol und Diethylalkohol.

13. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 10, wobei der andere Flüssigbrennstoff auf Kohlenwasserstoffbasis mindestens einer ist, ausgewählt aus der Gruppe bestehend aus Pentan, Hexan, Heptan, Octan, Nonan, Decan, Benzen und Aceton.

14. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt das Zuführen eines zerstäubten Flüssigbrennstoffs aus einer Bildung eines gesinterten Kuchens in einem Oberflächenschichtabschnitt des Sinterbetts (9) bis zum Abschluss des Sinterns aufweist.

15. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt das Zuführen eines zerstäubten Flüssigbrennstoffs in einem Bereich aufweist, in dem die Dicke einer Verbrennungs- und Schmelzzone 15 mm oder mehr beträgt.

16. Verfahren zum Herstellen eines gesinterten Erzes nach Anspruch 1, wobei der Flüssigbrennstoffzufuhrschritt das Zuführen eines zerstäubten Flüssigbrennstoffs aufweist, nachdem eine Verbrennungsfront eine Position erreicht hat, die sich 100 mm unterhalb einer Oberflächenschicht befindet.

17. Sintermaschine, aufweisend:

eine sich bewegende Palette (8);
eine Rohmaterialzufuhreinrichtung (5, 6, 7) zum Beschicken eines Sinterrohmaterials, das ein Feinerz und ein kohlenstoffhaltiges Material enthält, auf der Palette (8), um ein Sinterbett (9) auszubilden;
einen Zündofen (10) zum Zünden des kohlenstoffhaltigen Materials im Sinterrohmaterial auf der Palette;
eine Flüssigbrennstoff-Sprühvorrichtung (15), die an einer stromabwärtigen Seite des Zündofens vorgesehen ist und die einen Flüssigbrennstoff zerstäubt, um eine Teilchengröße von 100 μm oder weniger aufzuweisen, und den zerstäubten Flüssigbrennstoff auf dem Sinterbett versprüht; und
eine Windbox (11) zum Saugen von Luft zu einer unteren Seite der Palette,
wobei die Flüssigbrennstoff-Sprühvorrichtung (15) aufweist: eine Druckgaszufuhrquelle (21), eine Flüssigbrennstoffzufuhrquelle (22) und einen Sprühmechanismus (23), der einen Flüssigbrennstoff von der Flüssigbrennstoffzufuhrquelle (22) und ein Druckgas von der Druckgasquelle (21) mischt, um einen zerstäubten Flüssigbrennstoff auszubilden, und welche den zerstäubten Flüssigbrennstoff oberhalb des Sinterbetts (9) in einer horizontalen Richtung sprüht.

18. Sintermaschine nach Anspruch 17, wobei der Sprühmechanismus (23) aufweist: eine Transportleitung (23), die ein gemischtes Fluid aus dem komprimierten Gas und dem Flüssigbrennstoff transportiert und das eine abwärts gerichtete Neigung zu einer stromabwärtigen Seite hat; eine Verbindungsleitung (26), die mit einer unteren Flächenseite der Transportleitung in Verbindung steht; und eine Sprühdüse (28a, 28b), die an einer unteren Fläche der Verbindungsleitung (26) ausgebildet ist, sprüht den Flüssigbrennstoff in einer horizontalen Richtung und weist eine Abwärtsneigung in Richtung einer Ausstoßöffnung auf.

19. Sintermaschine nach Anspruch 17, wobei der Flüssigbrennstoff zumindest einer ausgewählt aus der Gruppe bestehend aus einem Flüssigbrennstoff auf Erdölbasis, einem Flüssigbrennstoff auf Alkoholbasis, einem Flüssigbrennstoff auf Etherbasis und einem anderen Flüssigbrennstoff auf Kohlenwasserstoffbasis ist, wobei jedes von diesen bei ungefähr Normaltemperatur im flüssigen Zustand ist.

20. Sintermaschine nach Anspruch 17, wobei das komprimierte Gas ein Gas ist, das mindestens eines aus flammenlöschendem Stickstoff, Kohlendioxid und Wasserdampf als eine primäre Komponente enthält.

21. Sintermaschine nach Anspruch 17, wobei die Flüssigbrennstoff-Sprühvorrichtung (15) einen Vorheizmechanismus zum Erwärmen des Flüssigbrennstoffs aufweist, so dass der Flüssigbrennstoff eine optimale Viskosität für dessen Zerstäubung aufweist, wenn er eine hohe Viskosität aufweist.

Revendications

1. Procédé pour produire un minerai fritté comprenant :

   une étape de chargement consistant à charger une matière première de frittage contenant un minerai fin et un matériau carboné sur une palette à déplacement circulaire (8) pour former un lit de frittage (9) ;
   une étape d'allumage consistant à allumer le matériau carboné dans le lit de frittage par un four d'allumage (10) ;
   une étape d'alimentation en combustible liquide consistant à apporter un combustible liquide atomisé ayant une taille de particule de 100 μm ou moins au-dessus du lit de frittage (9) après l'allumage ; et
   une étape de frittage consistant à aspirer de l'air par le biais d'une boîte à vent (11) disposée sous la palette (8) afin de produire le minerai fritté.

2. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel le combustible liquide atomisé a une taille de particule de 20 à 50 μm.

3. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend :

   l'apport d'un combustible liquide atomisé ayant une taille de particule de 100 μm ou moins sur le lit de frittage (9) ; et
   l'apport du combustible liquide atomisé dans le lit de frittage (9) dans un état où le combustible liquide atomisé est dilué à pas plus d'une concentration de combustion de limite inférieure à température ordinaire.

4. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel le combustible liquide atomisé a une concentration de pas plus d'une concentration de combustion de limite inférieure.

5. Procédé pour produire un minerai fritté selon la revendication 4, dans lequel la concentration se trouve dans une plage de 1% à 75 % de la concentration de combustion de limite inférieure.

6. Procédé pour produire un minerai fritté selon la revendication 5, dans lequel la concentration se trouve dans une plage de 4% à 25% de la concentration de combustion de limite inférieure.

7. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend la pulvérisation d'un combustible liquide atomisé ayant une taille de particule de 100 μm ou moins dans une direction horizontale au niveau d'un côté supérieur du lit de frittage (9).

8. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend :

   le mélange d'un combustible liquide et d'un gaz comprimé pour former un combustible liquide atomisé ; et
   la pulvérisation du combustible liquide atomisé au-dessus du lit de frittage (9).

9. Procédé pour produire un minerai fritté selon la revendication 8, dans lequel le gaz comprimé est un gaz contenant au moins un parmi de l'azote, du dioxyde de carbone et de la vapeur d'eau d'extinction de flamme en tant que composant primaire.

10. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel le combustible liquide est au moins un sélectionné dans le groupe constitué d'un combustible liquide à base de pétrole, d'un combustible liquide à base d'alcool, d'un combustible liquide à base d'éther, et d'un combustible liquide à base d'un autre hydrocarbure.

11. Procédé pour produire un minerai fritté selon la revendication 10, dans lequel le combustible liquide à base de pétrole est au moins un sélectionné dans le groupe constitué de pétrole lampant, de pétrole léger, et de pétrole lourd.

12. Procédé pour produire un minerai fritté selon la revendication 10, dans lequel le combustible liquide à base d'alcool est au moins un sélectionné dans le groupe constitué d'alcool méthylique, d'alcool éthylique, et d'alcool diéthylique.

13. Procédé pour produire un minerai fritté selon la revendication 10, dans lequel le combustible liquide à base d'un autre hydrocarbure est au moins sélectionné dans le groupe constitué de pentane, d'hexane, d'heptane, d'octane,

de nonane, de décane, de benzène, et d'acétone.

14. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend l'apport d'un combustible liquide atomisé à partir d'une formation d'un gâteau fritté dans une portion de couche de surface du lit de frittage (9) à un achèvement de frittage.

15. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend l'apport d'un combustible liquide atomisé dans une région dans laquelle l'épaisseur d'une zone de combustion et de fusion est de 15 mm ou plus.

16. Procédé pour produire un minerai fritté selon la revendication 1, dans lequel l'étape d'alimentation en combustible liquide comprend l'apport d'un combustible liquide atomisé après qu'un front de combustion a atteint une position située 100 mm sous une couche de surface.

17. Machine de frittage comprenant :

une palette à déplacement circulaire (8) ;
un dispositif d'alimentation en matière première (5, 6, 7) pour charger une matière première de frittage contenant un minerai fin et un matériau carboné sur la palette (8) pour former un lit de frittage (9) ;
un four d'allumage (10) pour allumer le matériau carboné dans la matière première de frittage sur la palette ;
un dispositif de pulvérisation de combustible liquide (15) qui est disposé au niveau d'un côté aval du four d'allumage et qui atomise un combustible liquide pour avoir une taille de particule de 100 μm ou moins et pulvérise le combustible liquide atomisé sur le lit de frittage ; et
une boîte à vent (11) pour aspirer de l'air vers un côté inférieur de la palette,
dans laquelle le dispositif de pulvérisation de combustible liquide (15) comprend : une source d'alimentation en gaz comprimé (21), une source d'alimentation en combustible liquide (22), et un mécanisme de pulvérisation (23) qui mélange un combustible liquide provenant de la source d'alimentation en combustible liquide (22) et un gaz comprimé provenant de la source d'alimentation en gaz comprimé (21) pour former un combustible liquide atomisé et qui pulvérise le combustible liquide atomisé au-dessus du lit de frittage (9) dans une direction horizontale.

18. Machine de frittage selon la revendication 17, dans laquelle le mécanisme de pulvérisation (23) comprend : un tuyau de transport (24) qui transporte un fluide mélangé du gaz comprimé et du combustible liquide et qui présente une pente descendante vers un côté aval ; un tuyau de communication (26) communiquant avec un côté de surface inférieure du tuyau de transport; et une buse de pulvérisation (28a, 28b) qui est formée au niveau d'une surface inférieure du tuyau de communication (26), pulvérise le combustible liquide dans une direction horizontale, et présente une pente descendante vers un orifice d'éjection.

19. Machine de frittage selon la revendication 17, dans laquelle le combustible liquide est au moins un sélectionné dans le groupe constitué d'un combustible liquide à base de pétrole, d'un combustible liquide à base d'alcool, d'un combustible liquide à base d'éther, et d'un combustible liquide à base d'un autre hydrocarbure, dont chacun est dans un état liquide à température approximativement ordinaire.

20. Machine de frittage selon la revendication 17, dans laquelle le gaz comprimé est un gaz contenant au moins un parmi de l'azote, du dioxyde de carbone et de la vapeur d'eau d'extinction de flamme en tant que composant primaire.

21. Machine de frittage selon la revendication 17, dans laquelle le dispositif de pulvérisation de combustible liquide (15) comprend un mécanisme de préchauffage pour chauffer le combustible liquide de telle sorte que le combustible liquide a une viscosité optimale pour l'atomisation de celui-ci quand il a une viscosité élevée.

FIG. 1

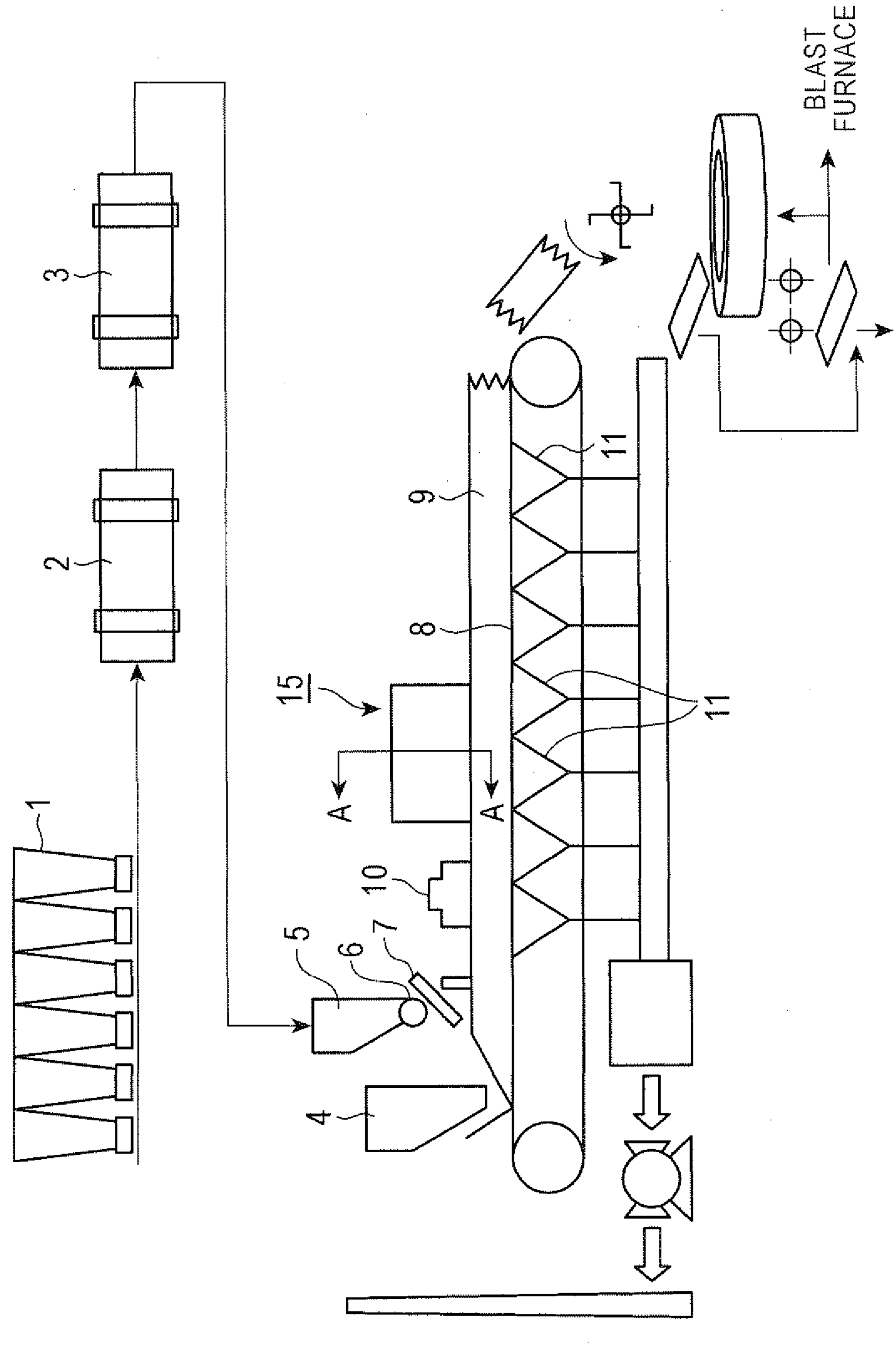


FIG. 2

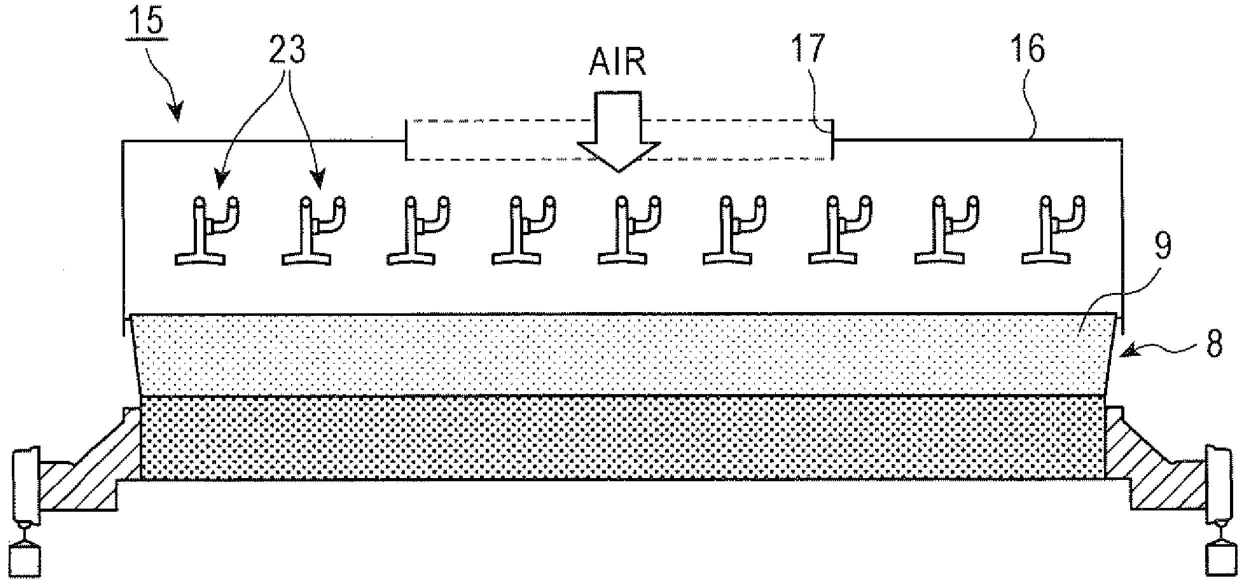


FIG. 3

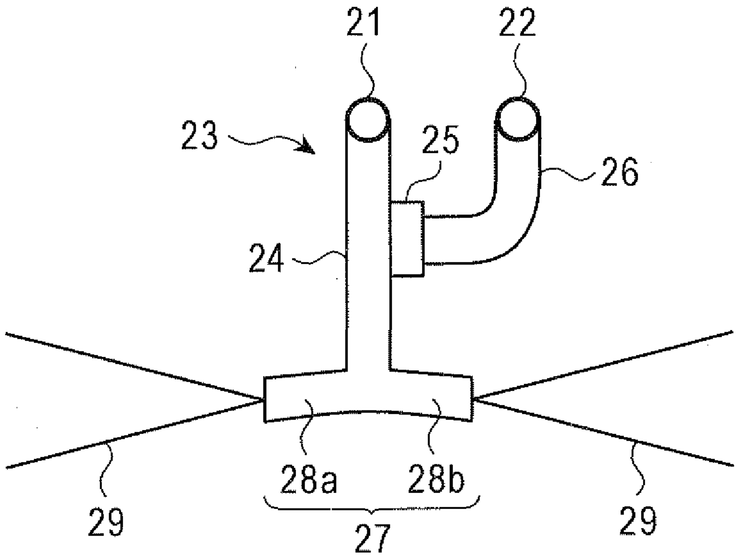


FIG. 4

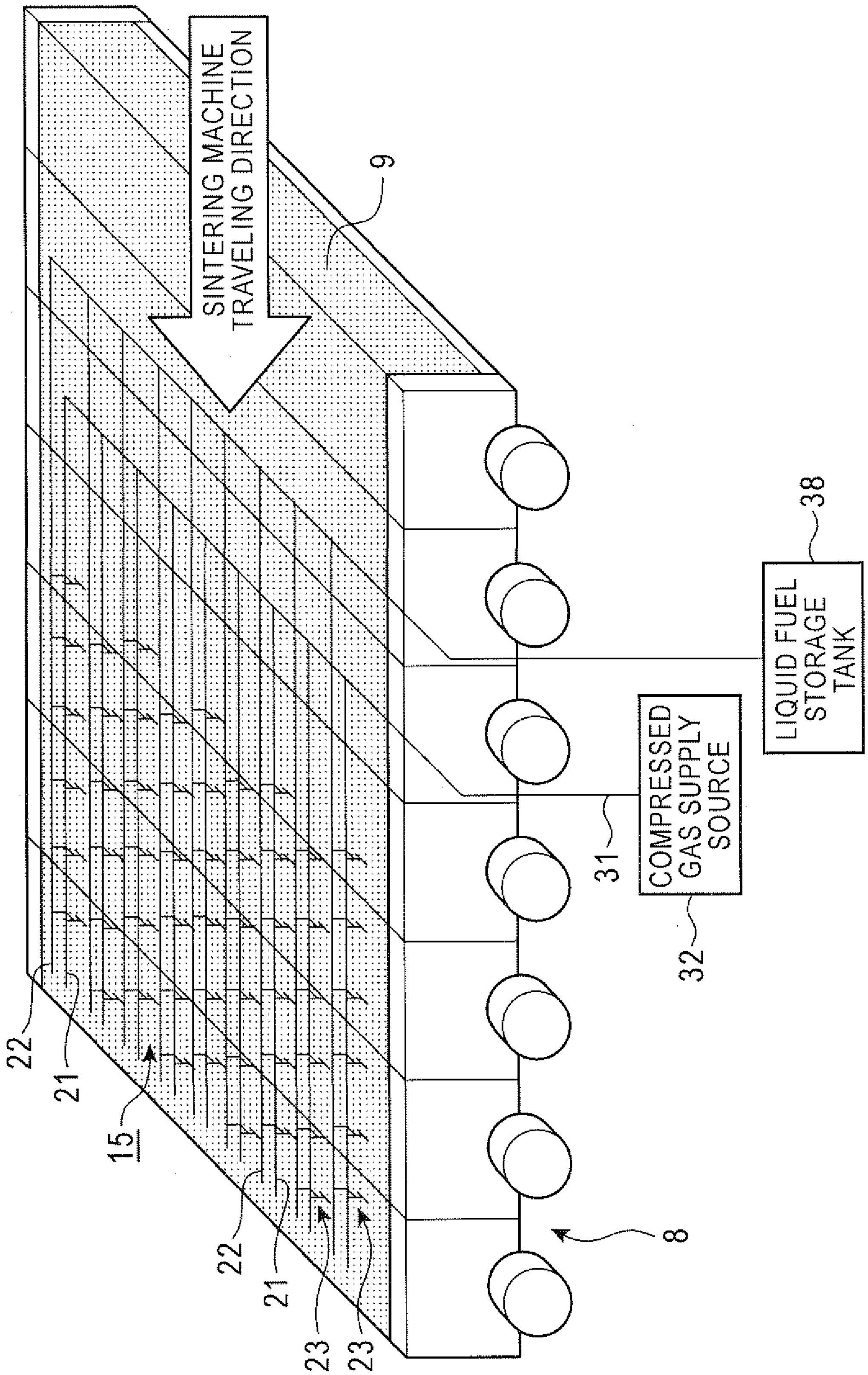

SINTERING MACHINE
TRAVELING DIRECTION
9
38
LIQUID FUEL
STORAGE
TANK
COMPRESSED
GAS SUPPLY
SOURCE
31
32
22
21
15
22
21
23
23
8

FIG. 5

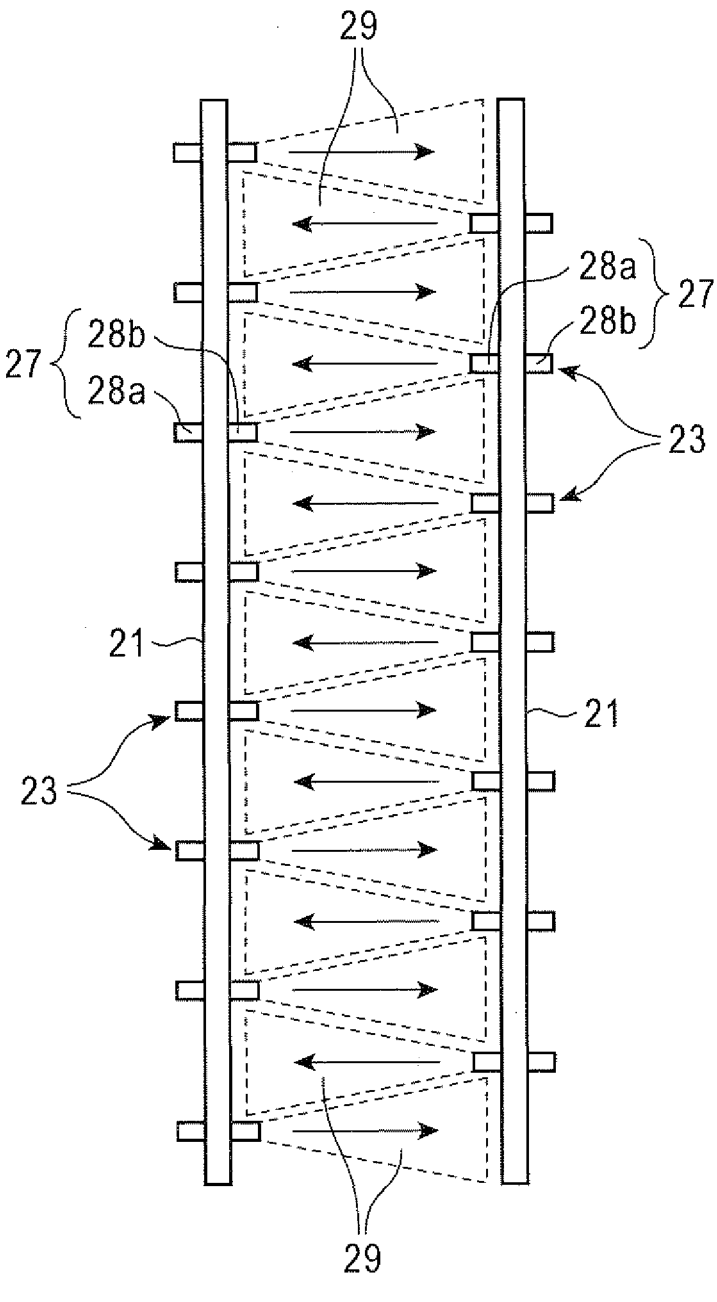


FIG. 6

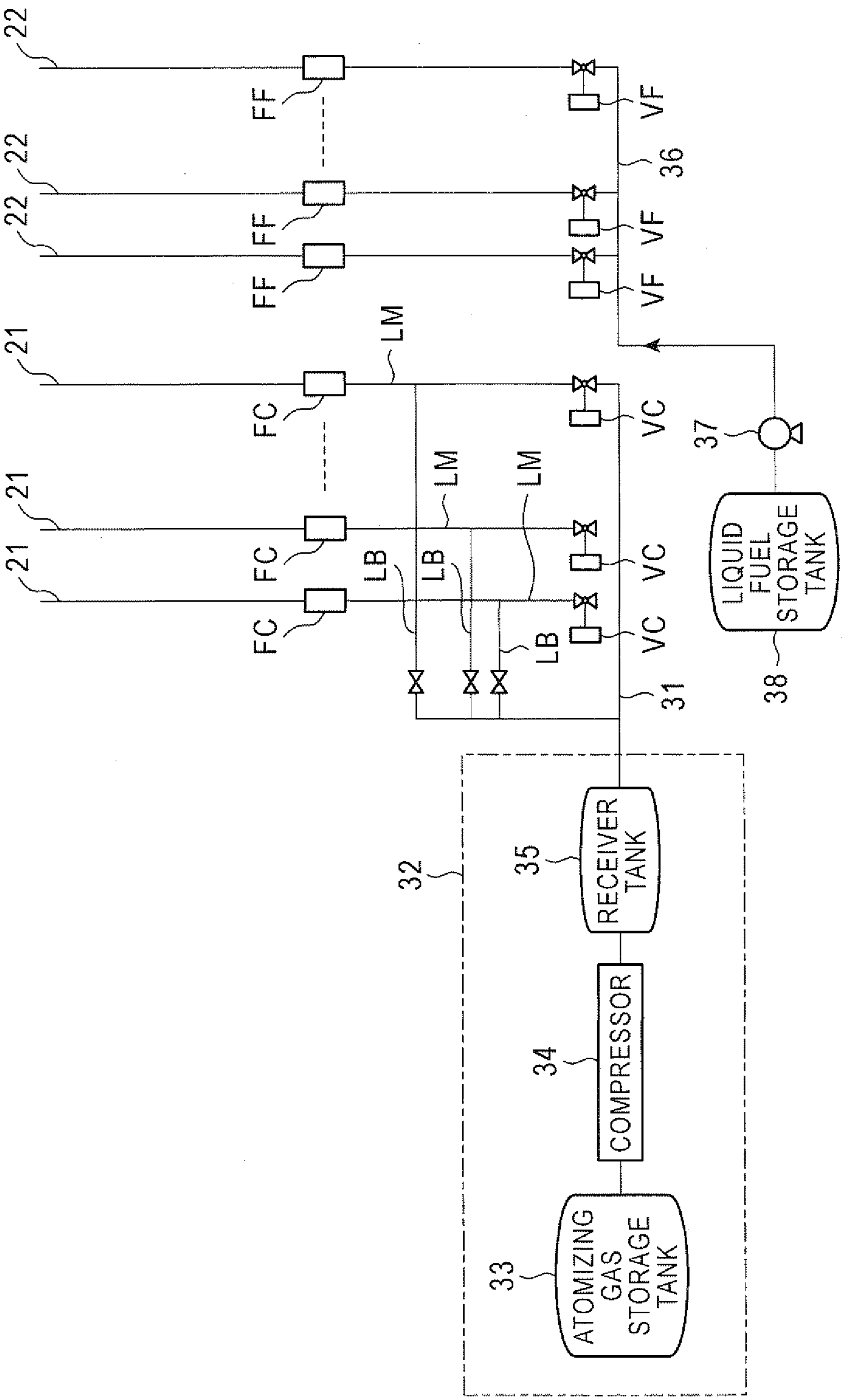

22
FF
VF
36
21
FC
LM
LB
VC
31
37
LIQUID FUEL STORAGE TANK
38
32
RECEIVER TANK
35
COMPRESSOR
34
ATOMIZING GAS STORAGE TANK
33

FIG. 7

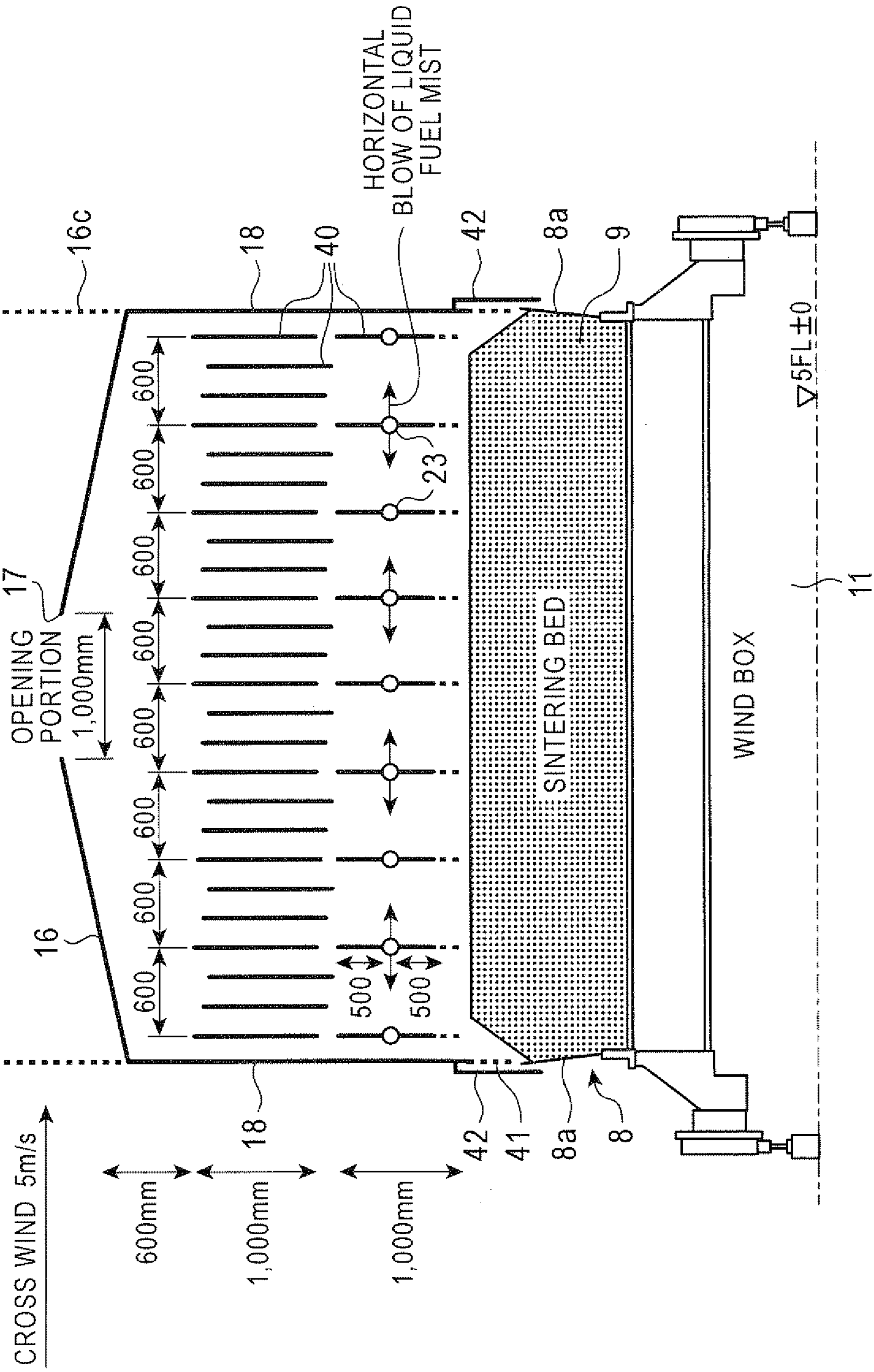

HORIZONTAL BLOW OF LIQUID FUEL MIST
16c
18
40
42
8a
9
5,000mm
OPENING PORTION
1,000mm
17
600
23
SINTERING BED
WIND BOX
11
∇5FL±0
16
500
18
42
41
8a
8
CROSS WIND 5m/s
600mm
1,000mm
1,000mm

FIG. 8

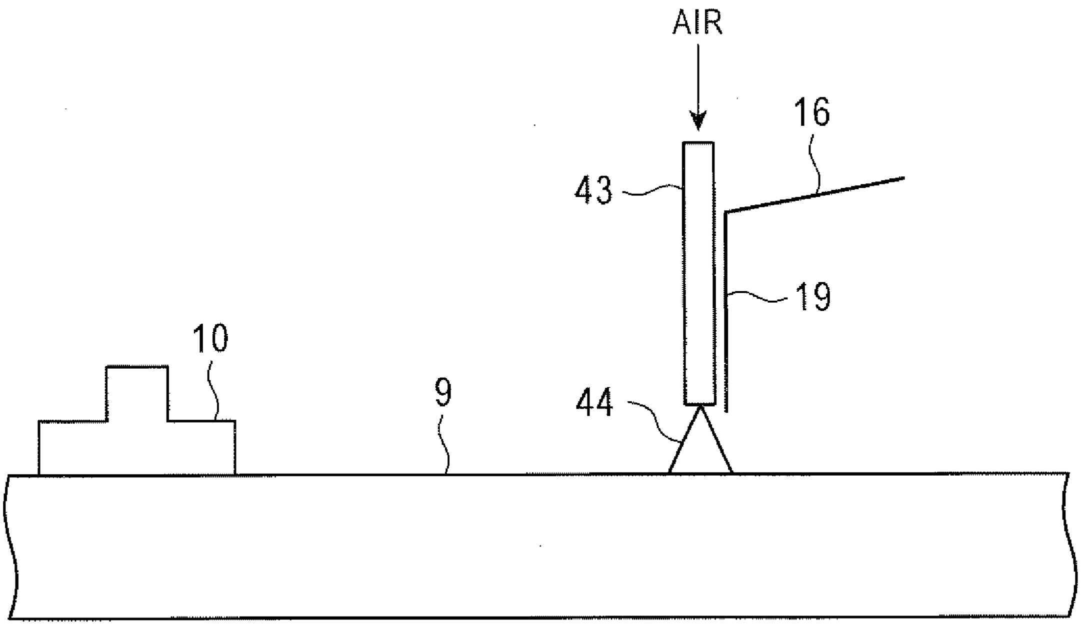


FIG. 9

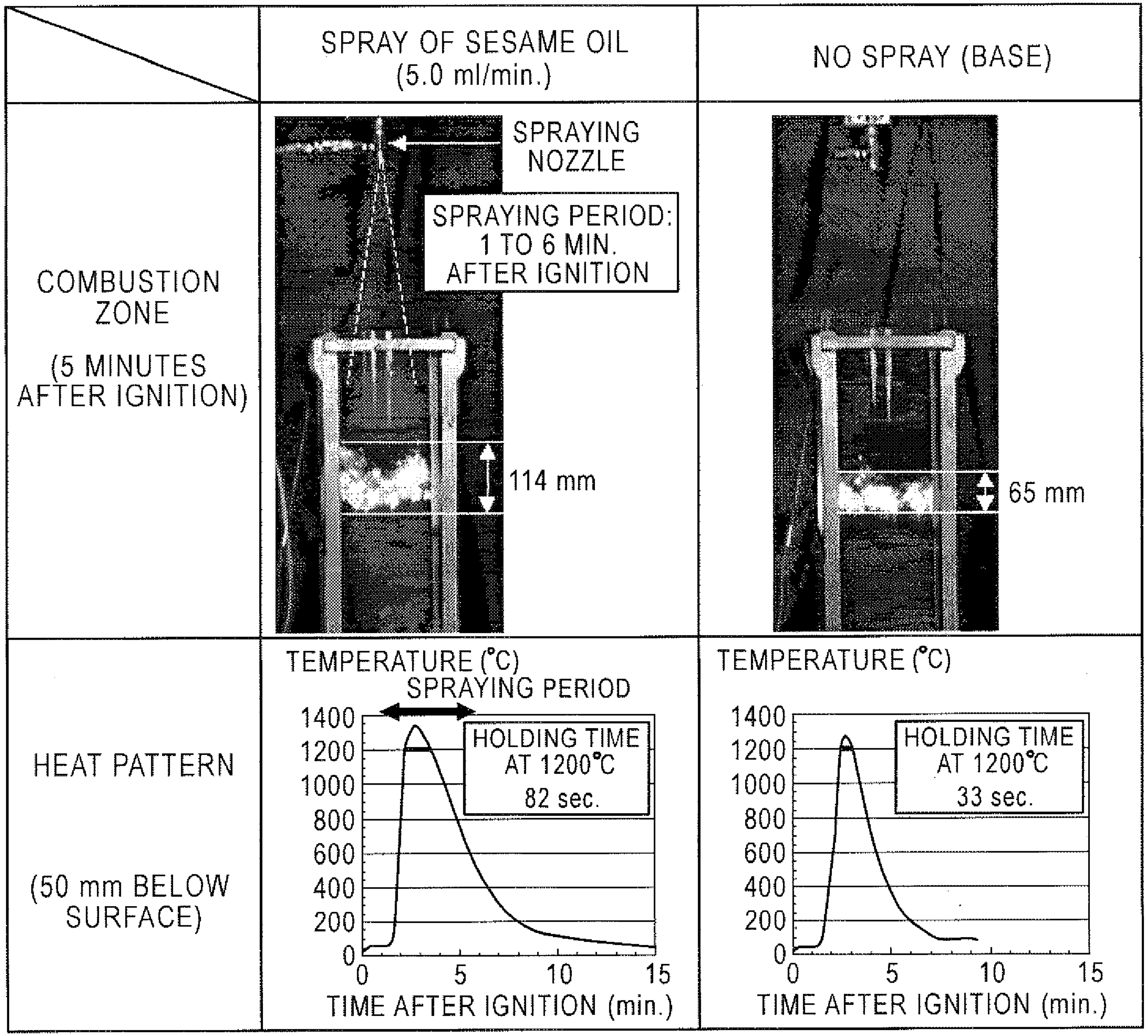

SPRAY OF SESAME OIL (5.0 ml/min.)
NO SPRAY (BASE)
COMBUSTION ZONE
(5 MINUTES AFTER IGNITION)
SPRAYING NOZZLE
SPRAYING PERIOD: 1 TO 6 MIN. AFTER IGNITION
114 mm
65 mm
HEAT PATTERN
(50 mm BELOW SURFACE)
TEMPERATURE (°C)
SPRAYING PERIOD
HOLDING TIME AT 1200°C 82 sec.
HOLDING TIME AT 1200°C 33 sec.
1400
1200
1000
800
600
400
200
0
0
5
10
15
TIME AFTER IGNITION (min.)

FIG. 10

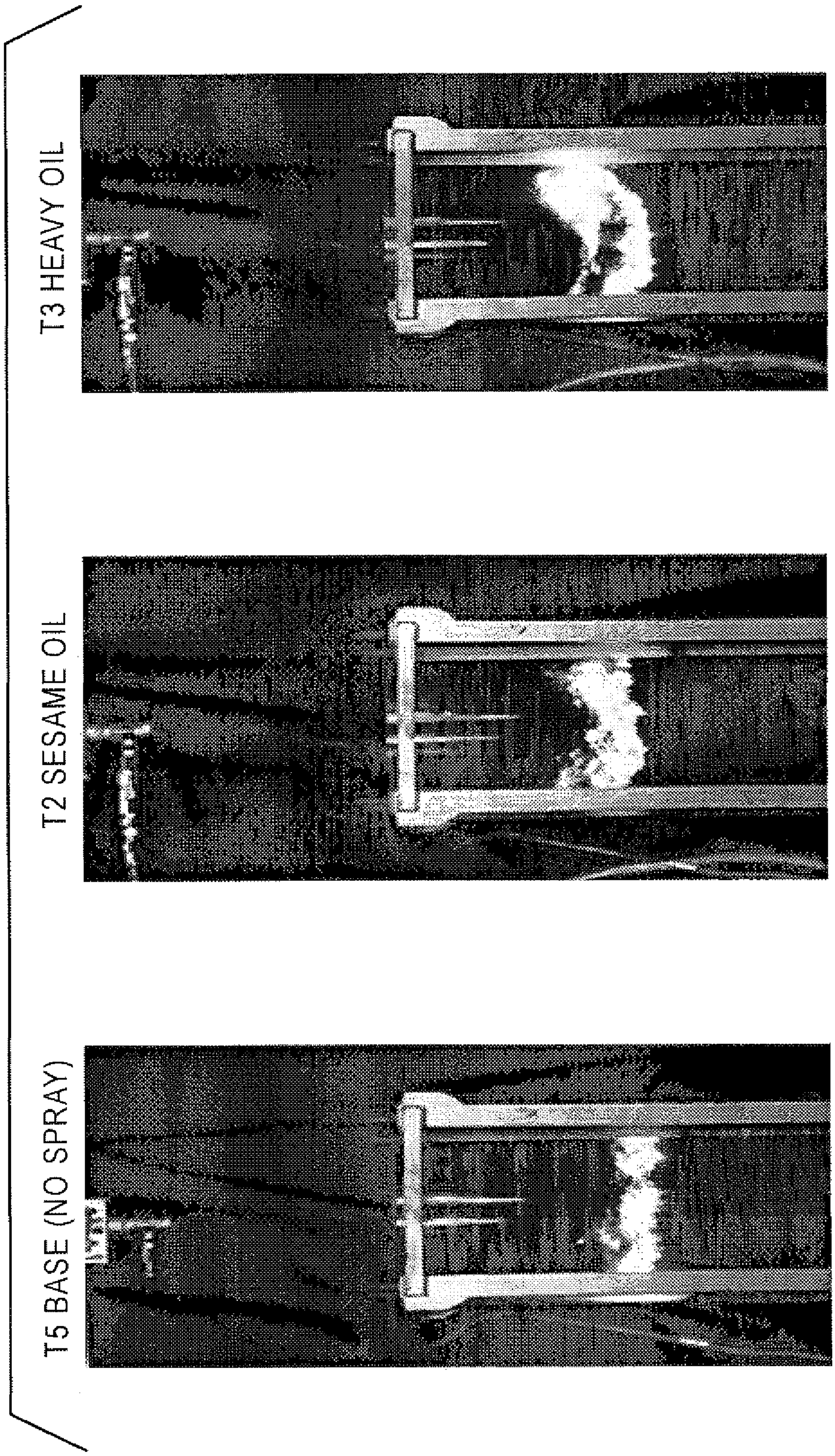


FIG. 11

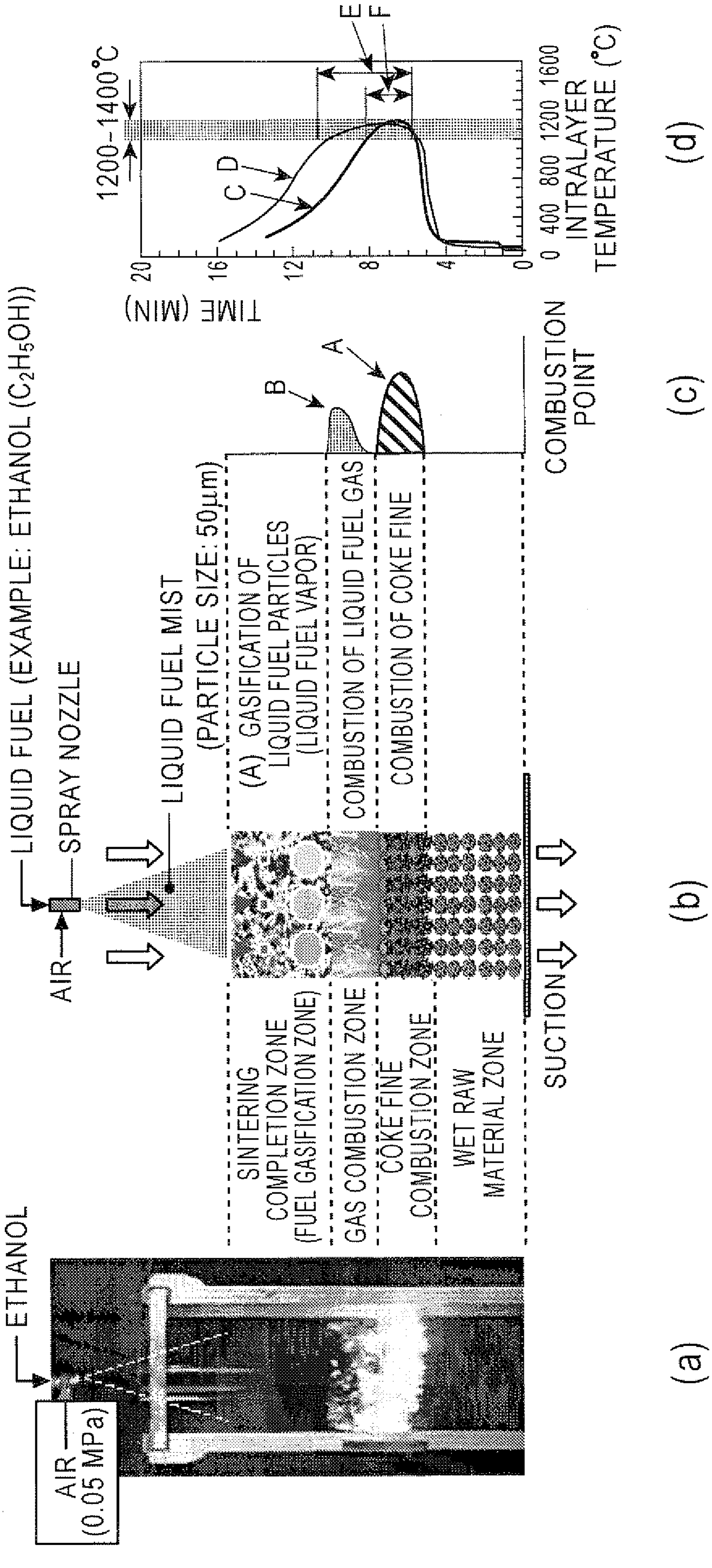

AIR
(0.05 MPa)
ETHANOL
(a)
LIQUID FUEL (EXAMPLE: ETHANOL (C_2H_5OH))
AIR
SPRAY NOZZLE
LIQUID FUEL MIST
(PARTICLE SIZE: 50μm)
SINTERING COMPLETION ZONE (FUEL GASIFICATION ZONE)
GAS COMBUSTION ZONE
COKE FINE COMBUSTION ZONE
WET RAW MATERIAL ZONE
SUCTION
(b)
(A) GASIFICATION OF LIQUID FUEL PARTICLES (LIQUID FUEL VAPOR)
COMBUSTION OF LIQUID FUEL GAS
COMBUSTION OF COKE FINE
B
A
COMBUSTION POINT
(c)
1200~1400°C
TIME (MIN)
C
D
E
F
INTRALAYER TEMPERATURE (°C)
(d)

FIG. 12

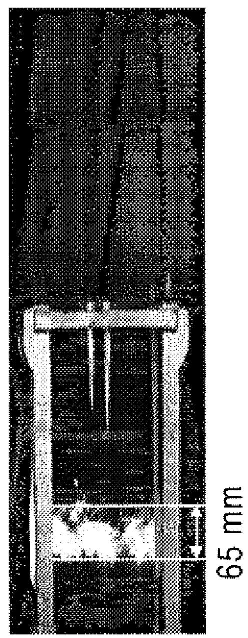
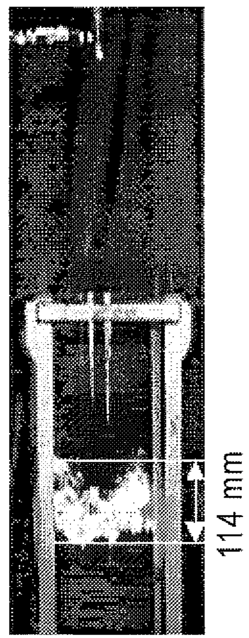
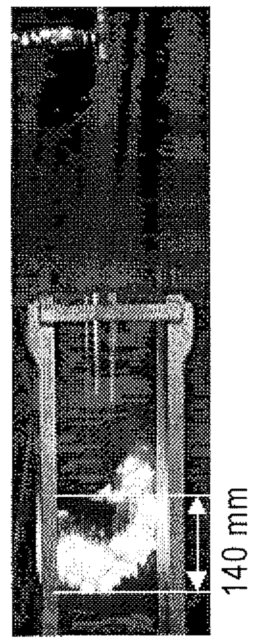
INJECTION FUEL	CONVENTIONAL SINTERING (ALL COKE)	HEAVY OIL (1.2 kg/t)	ETHANOL (1.8 kg/t)
COKE FINE RATIO (%)	5.0	4.8	4.8
SINTERED ORE STRENGTH (%)	75.1	77.8 (+2.7)	78.4 (+3.3)
COMBUSTION STATE			

FIG. 13

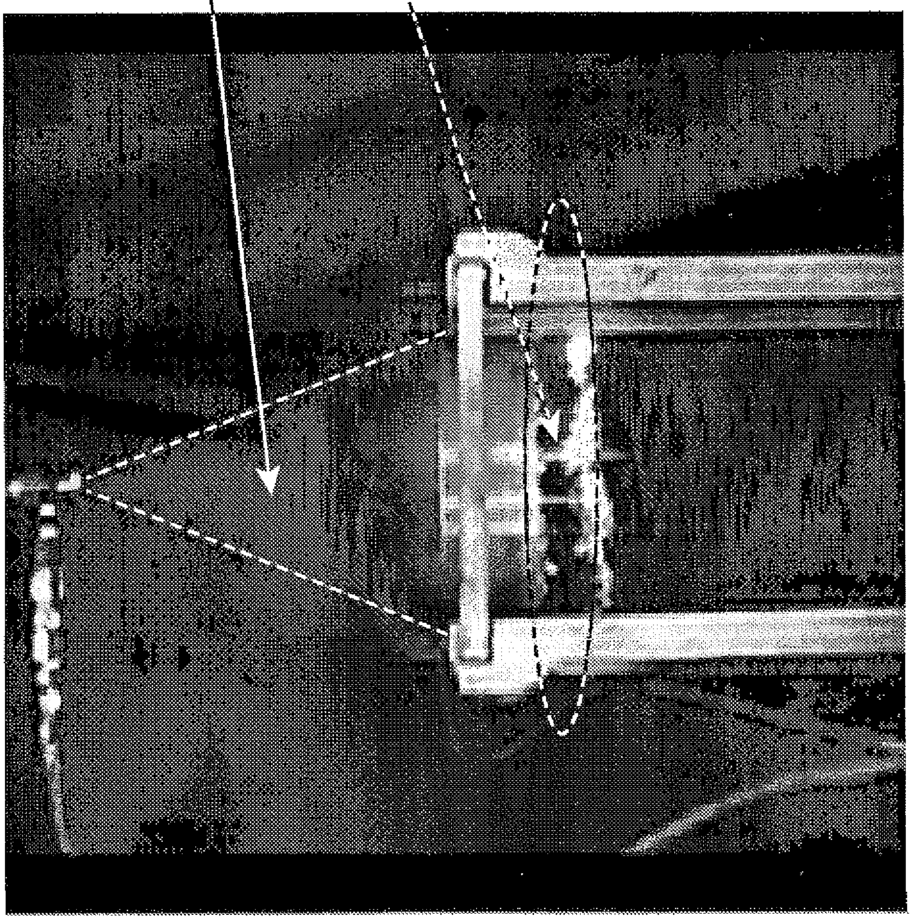

ETHANOL MIST
WHEN SURFACE OF CHARGED RAW MATERIAL LAYER IS AT IGNITION POINT (470°C) OF ETHANOL OR MORE, IGNITION OCCURS AS SHOWN IN LEFT VIEW.

FIG. 14

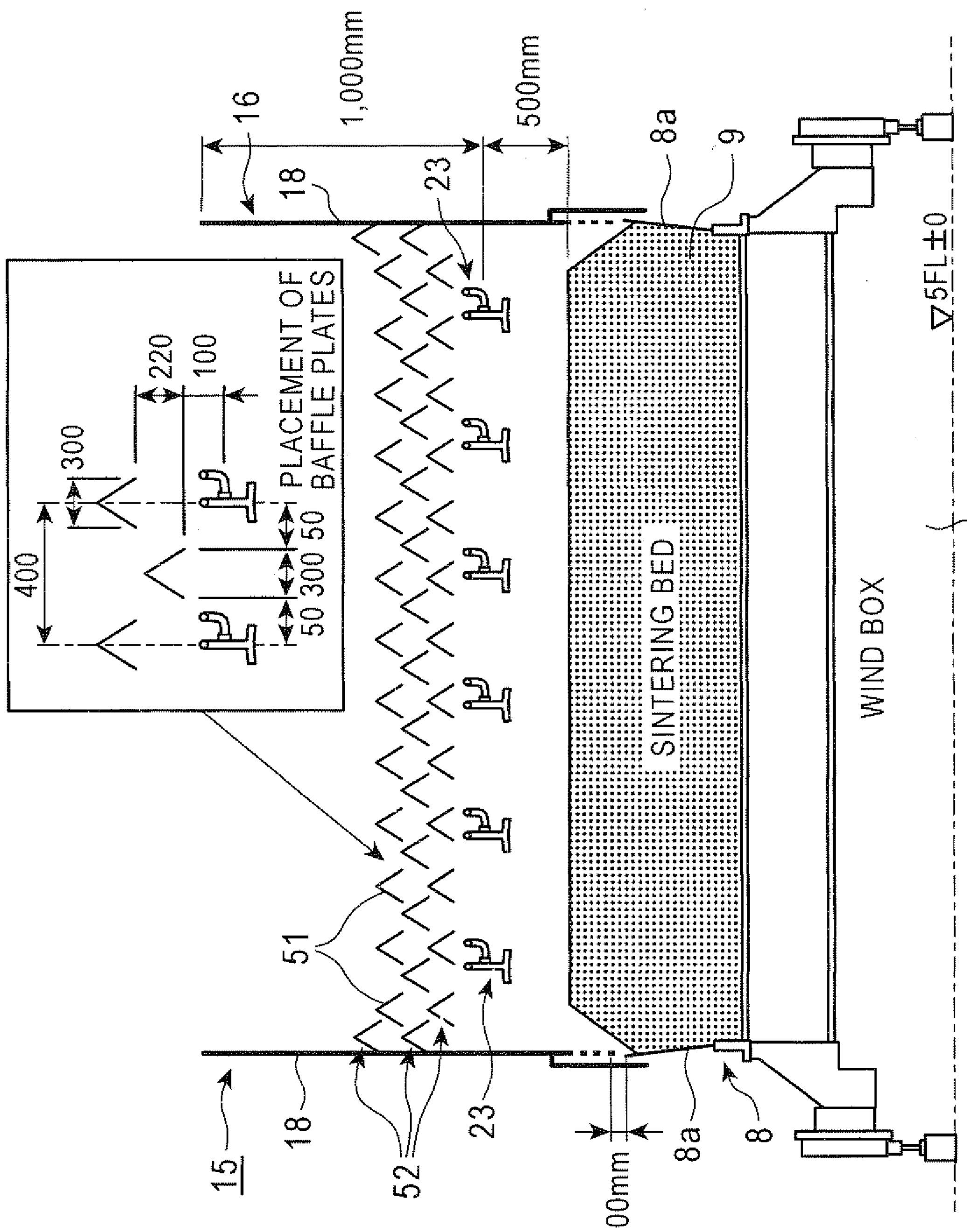

PLACEMENT OF BAFFLE PLATES
400
300
220
100
50 300 50
15
16
18
51
52
23
1,000mm
500mm
100mm
8a
8
9
SINTERING BED
WIND BOX
11
▽5FL±0

FIG. 15

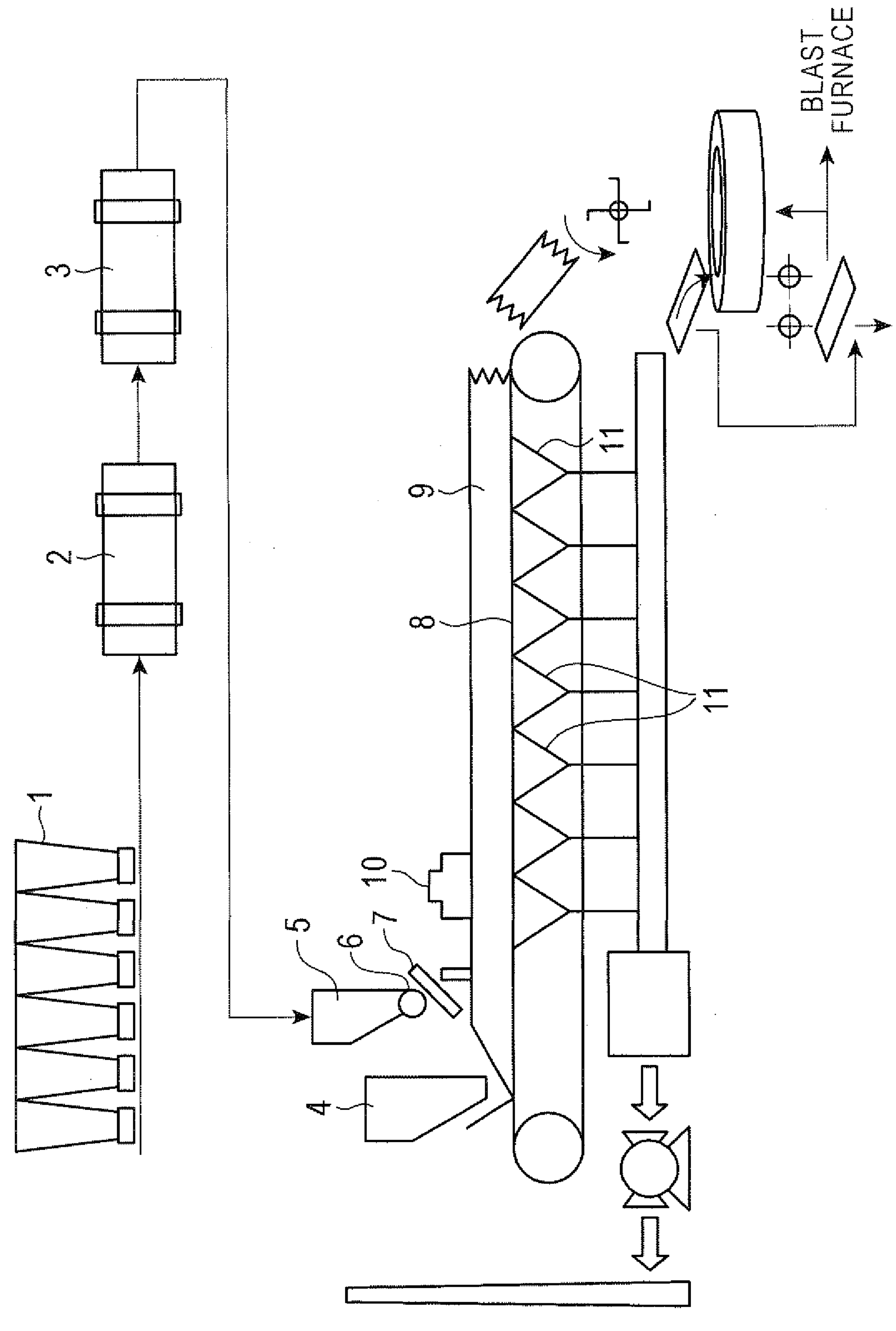


FIG. 16

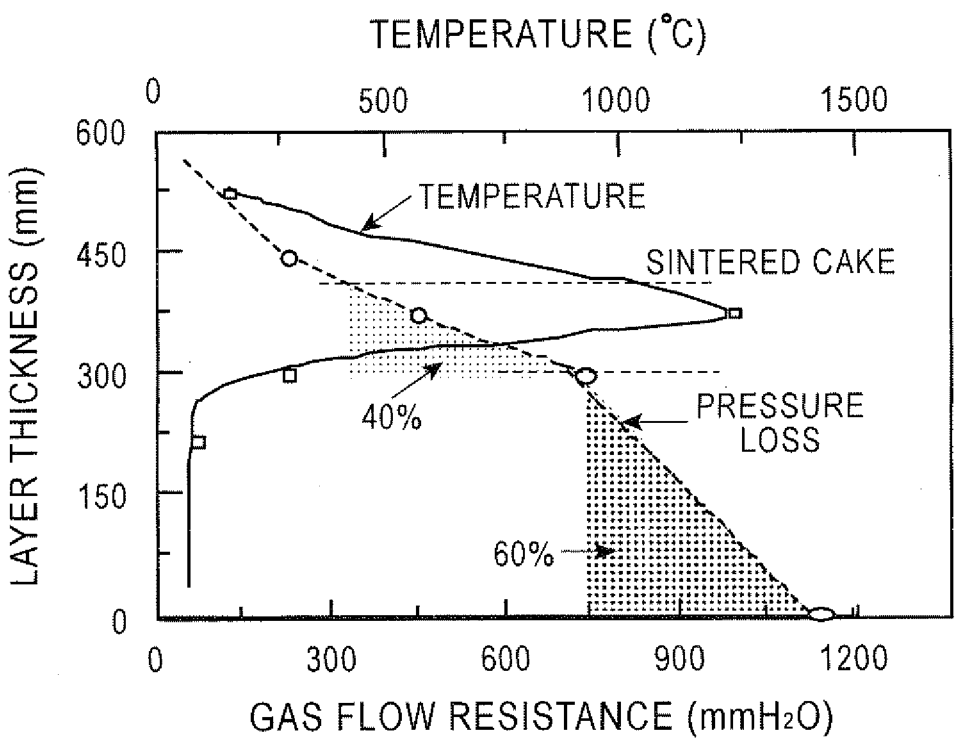

TEMPERATURE (°C)
0
500
1000
1500
600
450
300
150
0
LAYER THICKNESS (mm)
TEMPERATURE
SINTERED CAKE
PRESSURE
LOSS
40%
60%
0
300
600
900
1200
GAS FLOW RESISTANCE (mmH2O)

FIG. 17

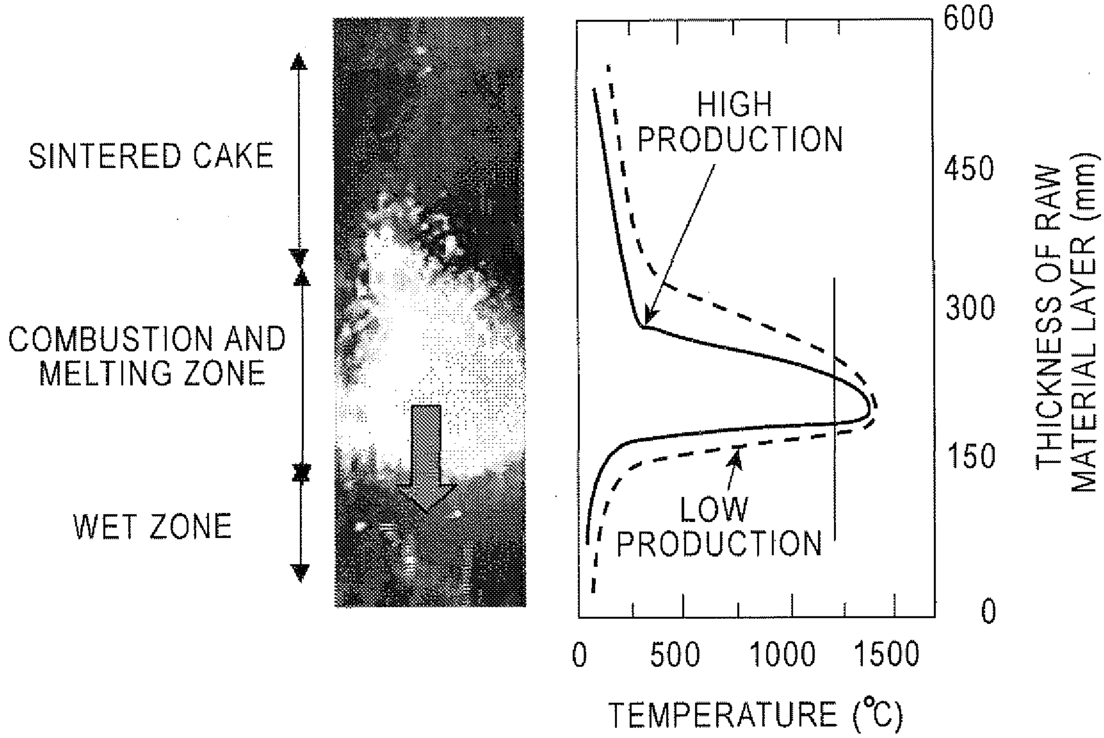
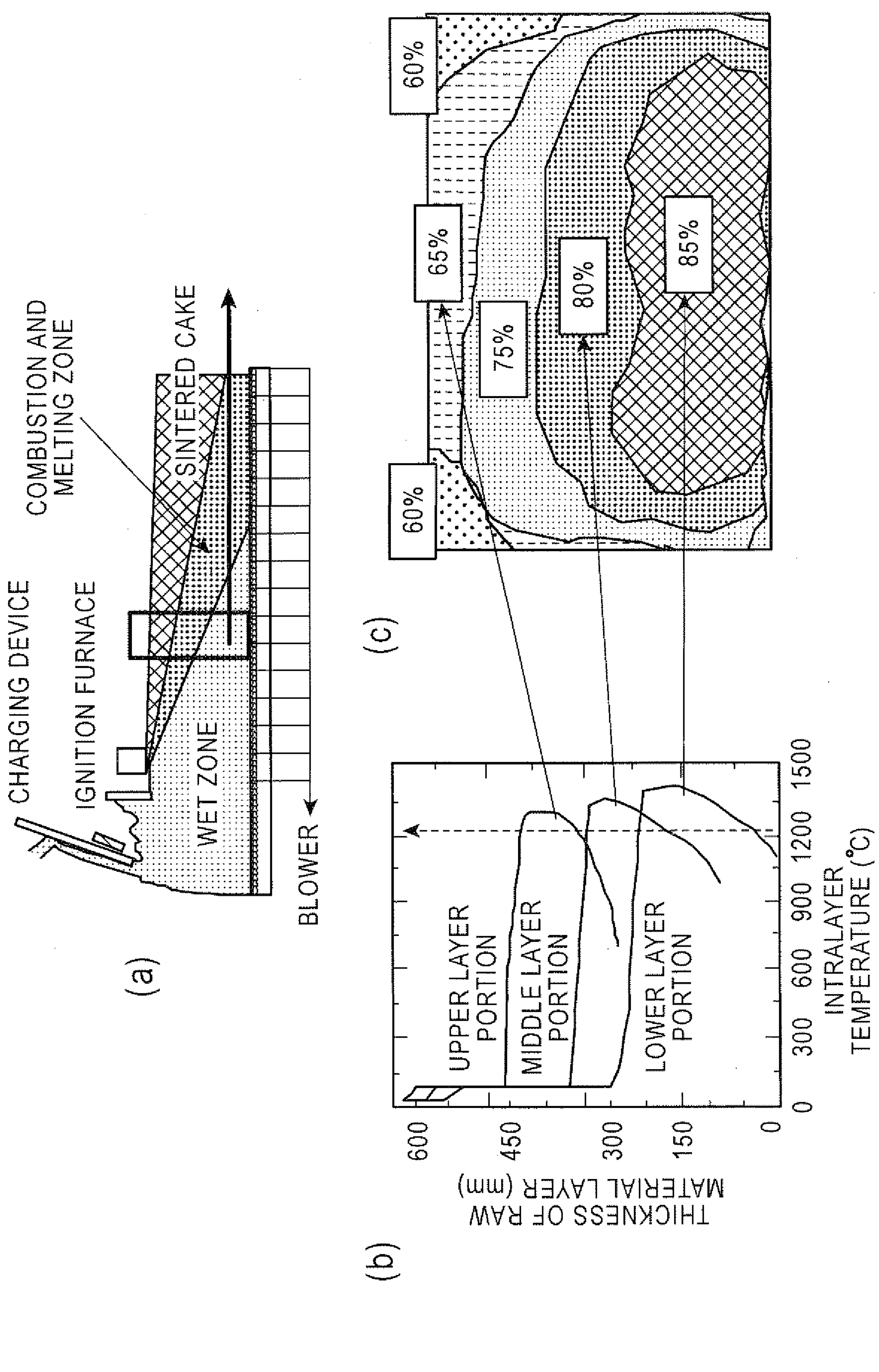

SINTERED CAKE
COMBUSTION AND MELTING ZONE
WET ZONE
HIGH PRODUCTION
LOW PRODUCTION
600
450
300
150
0
THICKNESS OF RAW MATERIAL LAYER (mm)
0
500
1000
1500
TEMPERATURE (℃)

FIG. 18


(a)
CHARGING DEVICE
IGNITION FURNACE
COMBUSTION AND MELTING ZONE
SINTERED CAKE
WET ZONE
BLOWER
(b)
THICKNESS OF RAW MATERIAL LAYER (mm)
600
450
300
150
0
UPPER LAYER PORTION
MIDDLE LAYER PORTION
LOWER LAYER PORTION
0
300
600
900
1200
1500
INTRALAYER TEMPERATURE (°C)
(c)
60%
65%
75%
80%
85%
60%

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 48018102 A **[0014]**
- JP 46027126 A **[0014]**
- JP 55018585 A **[0014]**
- JP 5311257 A **[0014]**
- WO 2007052776 A **[0014]**
- JP S5651536 A **[0015]**