June 21, 1966 A. M. SCHWARZ 3,257,195

SINTERING PROCESS

Filed July 28, 1964

Fig.1

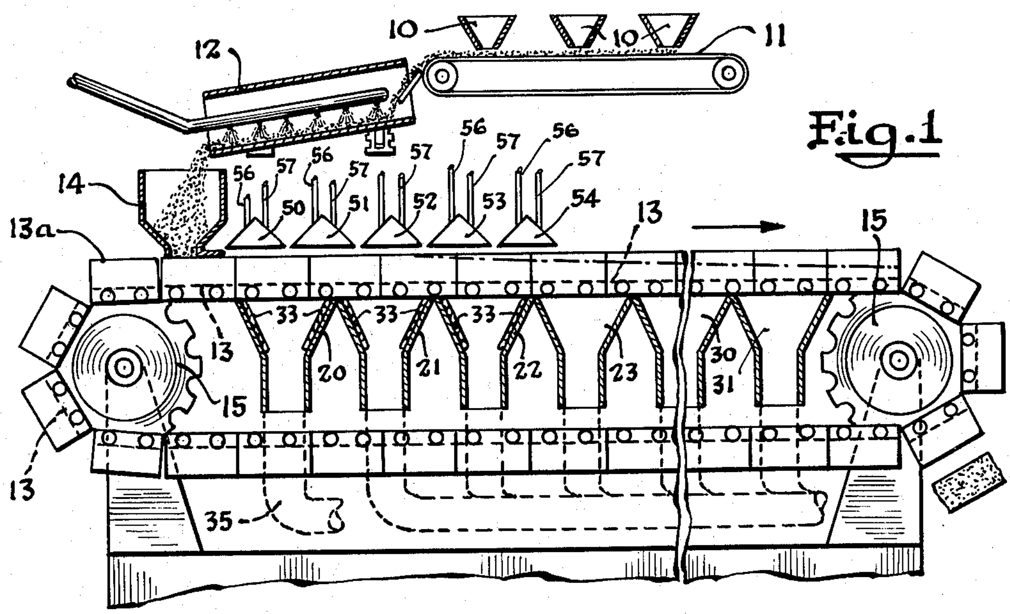


Fig.3

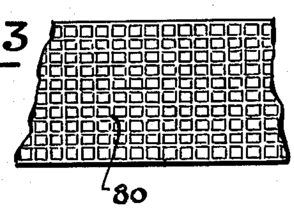
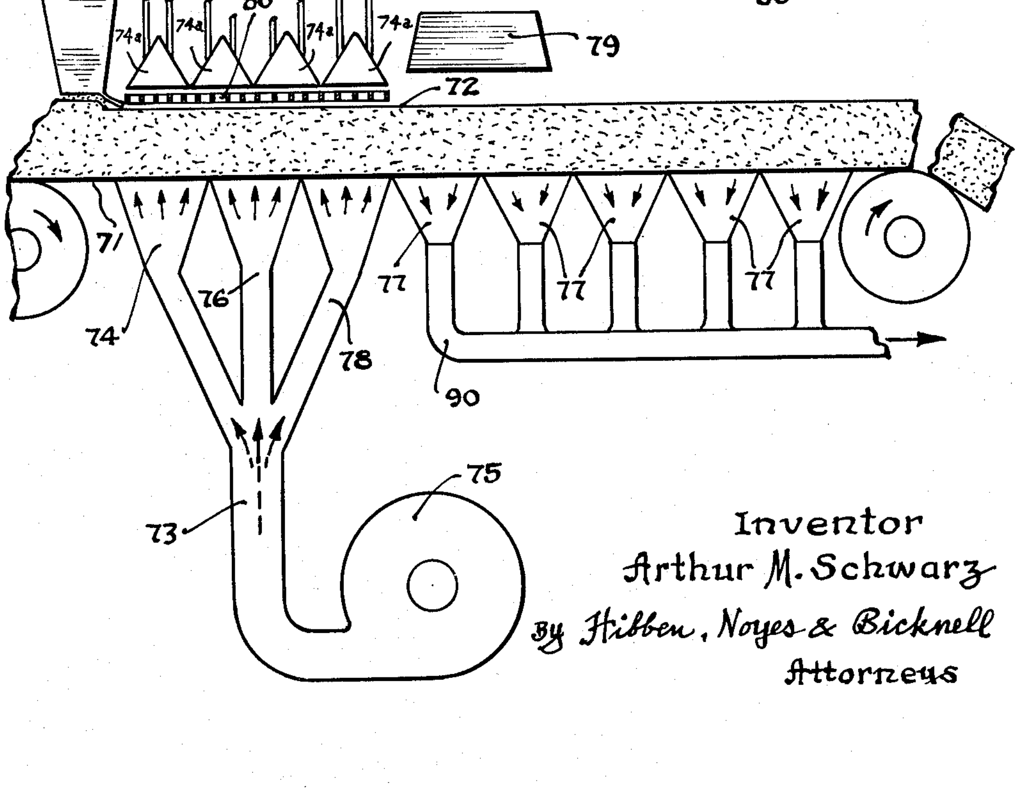


Fig.2



Inventor
Arthur M. Schwarz
By Hibben, Noyes & Bicknell
Attorneys

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SINTERING PROCESS

Arthur M. Schwarz, Munster, Ind., assignor to Inland Steel Company, Chicago, Ill., a corporation of Delaware

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This application is a continuation-in-part application of U.S. patent application Serial No. 56,541 filed September 16, 1960, now abandoned.

The present invention relates generally to a process of preparing ores and ore concentrates in an agglomerated form and more particularly to an improved process of continually sintering iron ore and the apparatus for carrying out said sintering process.

In recent years considerable work has been expended to increase the productivity of blast furnaces through increased use of agglomerated materials in the charge of the blast furnace. Much of this agglomerated material can be most effectively produced by a sintering process and it is of ever increasing importance to improve the efficiency and output of existing sintering apparatus and build more efficient sintering equipment in order to meet the increasing demand for sintered material.

Sintering as used in the metallurgical art designates a process of agglomeration of particles or granules of ore into a porous clinker-like mass by heating a homogeneous mixture of particles of an ore or a mixture of an ore and a combustible material to a state of incipient fusion while the particles are maintained in a quiescent bed. The sinter bed should contain a combustible material which will burn to give off sufficient heat to effect fusion of the particles. Unless the ore itself is combustible, the sinter feed is comprised of an ore or an ore concentrate admixed with a fuel, such as coke breeze.

In sintering iron ore the heat required to raise the iron ore particles to the temperature of incipient fusion is furnished by burning coal particles or other sources of carbon which are uniformly dispersed throughout the iron ore particles to form a homogeneous quiescent sinter bed between about 14 and 20 inches deep. The iron ore sinter mixture may also have a fluxing agent and other iron-containing particles admixed therewith.

The sintering process is generally carried out continuously on apparatus of the Dwight-Lloyd type which employs continuously moving permeable sinter grates for supporting a bed of sinter mixture. The conventional apparatus has associated therewith an ignition burner at one end for igniting the coal or coke fines in the sinter mixture at the top surface of the bed and a series of forced air outlets or "wind boxes" disposed adjacent the under side of the bed to draw air into the bed to sustain the burning of the coal or coke particles by subjecting the bed to a continuous forced air downdraft.

To facilitate drawing an adequate supply of air into the sinter bed economically, the bed must be reasonably permeable to the passage of gases. And, to provide a sinter bed with high permeability, particularly when the bed is composed of relatively fine ore particles or concentrates, it is highly desirable to pretreat or condition the sinter feed mixture so that the fine particles adhere to each other forming small agglomerates. When the feed mixture is deposited on the sinter grate in the form of small agglomerates, air or other oxygen containing gases can be drawn through the bed prior to ignition thereof much more easily and at less cost than would be possible without having pretreated the sinter feed mixture to form the small agglomerates (i.e. average particle size in the range of about ⅛ inch).

The small agglomerates are commonly produced by passing the sinter feed mixture through a mixing or tumbling apparatus, such as a pug mill, a rotary drum, or a disc mixer in the presence of sufficient moisture to make the particles adherent one to another. Sufficient moisture must be present to form small agglomerates having sufficient strength to retain their form when deposited on the sinter grate and while sustaining the weight of the upper portions of the bed. For a given feed mixture there is a critical moisture content which results in optimum pre-ignition gas permeability of the sinter bed. In general, a moisture content of from 7 to 10 percent by weight is required to form the desired small agglomerates.

In the conventional sintering process, after the sinter feed mixture in the form of small agglomerates has been placed on the sinter grate, ignited, and subjected to the usual downdraft required to sustain combustion in the bed, it has heretofore been found that the gas permeability of the unburnt portion of the sinter bed is much lower than before the bed was ignited and that a lower gas permeability remains until combustion approaches completion. The reduction in the gas permeability of the sinter bed which occurs after ignition of the bed appears to be a major factor in reducing the rate at which the fusion zone progresses through the sinter bed and causing a reduction in the overall rate of sintering.

It has been observed that after ignition and during combustion of the sinter feed on a downdraft sinter line, the moisture is carried downwardly through the bed in the waste gases and condenses on the lower portions of the sinter bed. The condensed moisture tends to fill the small air passages in the bed and is also absorbed by the small agglomerates to the extent that their structure is so weakened that the particles form a soft mud-like consistency, thus losing substantially all of the agglomerate structure and substantially reducing the gas permeability of the bed. The latter condition is particularly augmented by the large forced downdraft imposed on the sinter bed to effect good ignition of the sinter mixture by drawing air downwardly through the bed at a high velocity. In the usual downdraft sintering process the upper surface of the sinter bed will be observed to drop or "pack" about 2 to 3 inches when the sinter passes over the first wind box. This "packing" of the sinter bed thus appears to be an important factor in decreasing the permeability thereof and substantially reducing the rate of sintering.

In addition to a reduction in the gas permeability of the sinter bed due to "packing" of the lower section thereof, the sinter bed of the conventional downdraft sintering process frequently "slags" in a zone adjacent the upper surface and causes sealing of the bed which results in further reduction in the gas permeability of the bed and the rate of sintering. In view of the high capital outlays necessary for the construction of new sintering facilities, any increase in the rate of sinter production of existing or new sintering equipment is highly desirable.

It is, therefore, an object of the present invention to provide an improved process of agglomerating an ore which permits more economical sintering treatment of an ore at an increased rate without impairing the quality of the agglomerated sinter product.

It is also an important object of the present invention to provide an improved sintering process.

It is also an object of the present invention to provide an improved method of drying a moist, agglomerated ore for use in a sintering process.

It is also an object of the present invention to provide an improvement in sintering apparatus which permits sintering of the iron ore mixture at a substantially increased rate.

Other objects of the present invention will be apparent to those skilled in the art from the following detailed description and claims to follow when read in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic vertical sectional view of a continuous strand sintering apparatus;

FIG. 2 is a fragmentary schematic vertical sectional view of a modified sintering apparatus of the present invention; and

FIG. 3 is a fragmentary top plan view of a portion of the apparatus of FIG. 2.

It has now been discovered that the objects of the present invention can be readily achieved in a very economical manner and without extensive modification of the conventional downdraft sintering equipment by providing means wherein a sinter feed bed having a conventional composition and preconditioned with the required optimum percentage of surface moisture (about 7% to 10% by weight for conventional hematite and goethite ores) is subjected to controlled conditions of heating and forced draft, whereby a substantial proportion of the moisture in the sinter bed is removed prior to ignition of the sinter bed.

Heretofore, those skilled in the sintering art, being familiar with the studies showing conclusively that a substantial amount of moisture is required in the sinter feed mixture in order to have good agglomeration and increased gas permeability in the sinter bed before ignition, have assumed that the sinter bed must also have the same relatively high moisture content at the time of ignition and during combustion of the sinter mixture (i.e. at least about 6% by weight surface moisture), if the sinter bed is to have the required gas permeability. Contrary to this general presumption, however, it has now been found that, while the presence of moisture plays an important function in forming the particles of the sinter mixture into the desired small agglomerates, the moisture in the agglomerated sinter mixture during the actual sintering operation is not required, does not contribute to the efficient production of the sinter product, and, in fact, is found to be highly detrimental to the most economical production of the sinter product. Thus, it has been discovered that by removing a substantial proportion of the moisture from the pelletized sinter feed mixture before ignition thereof and under controlled conditions, preferably after the bed is formed on the continuously moving sinter bed conveyor means, it is possible to achieve a very significant increase in the rate of sintering without destroying the agglomerate structure of the sinter bed or causing any impairment of the good quality of the sinter product. For example, a very substantial increase in the sintering rate can be obtained by reducing by about 50% the concentration of the water of hydration of an ore normally having a large amount of water of hydration and/or by substantially removing or reducing by at least about 50% the amount of surface moisture of the agglomerated ore prior to ignition of the sinter bed.

It has been found possible to remove the surface moisture and the water of hydration from an ore prior to agglomerating and formation of the sinter bed by contacting the finely divided ore in a rotary kiln or a fluidized bed calcining unit with hot gases having a temperature of about 700–1000° F. Since a considerable amount of water (7–10% by weight) is generally added to the ore during the formation of the agglomerates comprising the sinter bed and since it has been found that this amount of moisture is not required to obtain good permeability of the bed during sintering and in some instances actually impairs the permeability thereof, it is considered advisable and preferable in many instances to remove the water of hydration and surface moisture from the agglomerated ore forming the sinter bed immediately before igniting the sinter bed. A particularly advantageous way of removing water from the sinter bed is by providing a section of the sintering apparatus at the forward end thereof with means for forcing a heated gas through the bed prior to ignition of the bed. In the apparatus of FIG. 1, means are provided for applying either an updraft or downdraft drying gas flow, and in FIG. 2 means are provided for applying a strong updraft drying gas flow.

The predrying of the agglomerated ore sinter mixture on the sinter bed can be effected in accordance with one embodiment of the present invention by updraft drying with preheated air having a temperature of from about 500°–800° F., whereby substantial benefits are derived as a result of removing substantially all the surface moisture from the lower portion of the sinter bed or from the entire bed and from "fluffing" of the bed due to the hot gas being forced or drawn upwardly therethrough. Where desired, as when the ore contains a large amount of water of hydration, the bed can be treated with preheated air having a temperature of 800°–1100° F. which is sufficient to remove substantially all of the surface moisture and the water of hydration from the lower half of the sinter bed while also removing all of the surface moisture but only part of the water of hydration from the upper half of the sinter bed.

The benefits of the predrying sintering method are shown by the following experimental results:

Total Moisture Content of Sinter Bed at Time of Ignition	Sintering Rate, Inches Per Minute
7% water of hydration+9% surface water	.80
7% water of hydration+3% surface water	1.06
6% water of hydration+0% surface water	1.27
3.5% water of hydration+9% surface water	.96
2% water of hydration+9% surface water	1.12
3.5% water of hydration+0% surface water	1.39

In FIG. 1 of the drawing is shown schematically a sintering apparatus which can be employed in the process of the present invention wherein a plurality of supply bins **10** feed finely divided iron ore, coke breeze, limestone, or other ingredients of the sinter mixture onto a belt conveyor **11** which charges the several ingredients into a rotary drum-type mixture **12** wherein water is added to slightly moisten the mixture (7–10% moisture on a weight basis) and wherein the ingredients are uniformly mixed to form small agglomerates for imparting high gas permeability to the sinter bed formed therefrom. Thereafter, the homogeneous mixture is fed from the hopper **14** onto a continuously traveling gas permeable grate **13** which has the usual side plates **13***a* forming pallets for retaining the sinter mixture as a uniform layer or sinter bed. The grate **13** is continuously moved in a clockwise direction by suitable power driven sprockets **15**.

A plurality of contiguous wind boxes **20–31** are positioned below the traveling grate **13** with the top or head section of each wind box closed by the grate **13**. The lower ends or discharge legs of each of the wind boxes are preferably connected to headers **35** which have a suitable means associated therewith to provide an updraft or downdraft within the wind boxes. Disposed above the side plates **13***a* of the moving grate **13** are a plurality of adjustable headers **50–54** which are adapted to receive hot gases passed through the bed or supply hot gases to the bed by means of conduits **56, 57**, as desired.

In FIG. 2 of the drawing is schematically shown additional apparatus for performing the process of the present invention wherein a sinter feed bed which is formed in the conventional manner is heated to remove a substantial proportion of the moisture therein prior to ignition by applying hot gases to the underside of the sinter bed supported on a gas permeable grate and forcing the gases upwardly through the bed until preferably most of the surface moisture is removed from the bed. The gases are passed upwardly through the bed at a sufficiently high velocity to "fluff dry" the sinter bed without blowing the small agglomerated particles out of the bed, thereby permitting the fusion front to pass through the sinter bed at a very high rate after ignition and during the actual sintering operation. In order to provide the desired "fluffing" of the sinter bed by upward flow of gases through the bed without disturbing or appreciably altering the bed structure, a perforated cover plate **80** is preferably placed in contact with the upper surface of the sinter bed. If desired, of course, heat can also be simultaneously applied to the upper surface of the sinter bed by means of gas heaters, radiant heaters, or the like. Following the removal of the moisture in the bed, the sinter mixture can be ignited and sintered in the usual manner.

In the apparatus shown in FIG. 2 of the drawing a sinter mixture feed hopper **70** is disposed above one end of a continuously moving endless grate **71** which is adapted to support thereon a sinter bed **72** having a uniform depth of about 10 to 16 inches.

On the opposite side of the sinter bed **72** from the hopper **70** and spaced a short distance inwardly thereof are one or more gas conduits **73** having the blower outlet end portions **74, 76** and **78** thereof extending the width of the sinter bed and contacting the lower surface of the grate **71**. The conduits **73** are connected with a suitable blower means **75** and preferably having means associated therewith for heating the gases.

A perforated cover plate **80** is positioned transversely of the sinter bed so that the lower surface of the plate **80** substantially contacts the upper surface of the bed **72** and extends longitudinally from about the leading edge of the first outlet end portion **74** to the trailing edge of the last outlet end portion **78**.

A plurality of contiguous wind boxes **77** are arranged below the sinter bed and extending from the last outlet end portion **78** to about the end of the sinter line. Each of the wind boxes is closed at the top by the moving grate **71** and has the lower end thereof connected to a header **90** which has a suction means (not shown) associated therewith. If desired, dampers can be placed in the outlets **74, 76** and **78**, and in the wind boxes **77**. Also, above the outlets **74, 76** and **78** are wind boxes or headers **4*a*** to receive the gases from the outlets. Disposed above the first one or two wind boxes **77** and spaced longitudinally of the cover plate **80** is a standard ignition hood **79** which is adapted to ignite the upper surface of the sinter bed **72**.

In operating the apparatus of FIG. 2, a sinter mixture of conventional composition and containing the usual 7 to 10% by weight water is deposited on a gas permeable sinter gate **71** immediately in front of the first blower outlet **74**. Preheated gas heated to about 500° F.–800° F. is discharged from outlets **74, 76** and **78** at a substantial pressure to provide a gas flow in the range of about 200 to 400 cu. ft. per minute through each square foot of sinter bed, the moist sinter mixture is simultaneously dried and "fluffed" as it passes over the blower outlets **74, 76** and **78**. The cover plates **80** contacts the surface of the agglomerates forming the sinter bed **72** and prevents the sinter mixture being disturbed, carried away or entrained in the blower gases without, however, interfering with the removal of the moisture vapor in the heated gases.

After the sinter bed has traversed the section of the sintering apparatus having the blower outlets therebelow which "fluff dry" the sinter mixture, the sinter bed is ignited in the usual manner as it passes below the conventional ignition hood **79** and the sintering reaction takes place in the usual manner except that sintering proceeds at an increased rate due to the greater gas permeability of the sinter bed and without any decrease in the quality of the sinter product.

It will, of course, be understood that here, as in the first embodiment described heretofore, the heated gases used to pre-dry the sinter mixture before ignition thereof can be obtained by recirculating the exhaust gases obtained from the remaining wind boxes **77** or by any means known to those skilled in the art.

Whereas an iron ore sinter mixture has been used to illustrate the process of the present invention in the specific embodiment thereof, it should be understood that other ores pretreated to form moistened small agglomerates or which naturally occur in small moist agglomerated form can be dried or sintered in accordance with the present process. For example, among the ores which can be thus dried or sintered are zinc sulphide and other sulphurous ores, some of which are combustible without the addition of coke or fuels, nickel speiss, arsenous ores, lead oxide and the like ores which are commonly roasted, dried, or sintered. In each instance, the fundamental object is to lower the total moisture content of the sinter bed by removing most of the surface moisture and preferably at least a part of the water of hydration prior to igniting the sinter bed in order to avoid the need of carrying out all the drying and dehydrating of the sinter bed by the combustion gases of the fusion zone.

It will also be understood that the process of the present invention can be used to dry other agglomerated ores and material, such as pelletized iron ores wherein the pellets formed have a size substantially larger than the agglomerates of a sinter bed and which are simply surface hardened rather than completely fused. Thus, the herein disclosed improved procedure and means for removing moisture from a bed of agglomerated material has definite utility even when a sintering operation is not used in conjunction therewith.

Others may practice the invention in any of the numerous ways which are suggested to one skilled in the art, by this disclosure, and all such practice of invention are considered to be a part hereof which fall within the scope of the appended claims.

I claim:

1. In a process of continuously sintering a finely divided ore having about 7% by weight water of hydration including continuously moving longitudinally along a sintering apparatus a horizontally disposed sinter bed composed of an agglomerated combustible homogeneous mixture comprising finely divided particles of iron ore which have been moistened with water to provide at least about 7% by weight surface moisture to facilitate agglomeration of said mixture and formation of said sinter bed having a high gas permeability and prior to ignition of said bed exposing a surface thereof to a transverse flow therethrough of a heated gas having a temperature above the vaporization temperature of water but insufficient to initiate combustion in said bed, the improvement comprising; passing said heated gas through said sinter bed until substantially all the surface moisture is removed from the entire sinter bed and until said water of hydration of said ore is reduced to a maximum of about 3.5% by weight, and thereafter igniting a surface of said sinter bed and maintaining a controlled draft of an oxygen containing gas to sustain combustion therein until a fusion zone passes entirely through said bed; whereby packing of said sinter bed is avoided and said high gas permeability is substantially maintained throughout the sintering operation to effect a rapid rate of sintering.

2. A sintering process as in claim **1**, wherein said heated gas has a temperature between about 800° F. and 1100° F.

3. In a process of continuously sintering a finely divided iron ore including continuously moving longitudinally along a sintering apparatus a horizontally disposed sinter bed composed of an agglomerated combustible homogeneous mixture of finely divided iron ore particles which have been moistened with water to provide at least about 7% by weight surface moisture to facilitate agglomeration of said mixture and formation of said sinter bed having a high gas permeability, and prior to ignition of said bed exposing a surface of the sinter bed to a transverse flow therethrough of a heated gas having a temperature above the vaporization temperature of water and insufficient to initiate combustion in said bed, the improvement comprising; passing said heated gas having a temperature above 500° F. and below 800° F. through said bed until substantially all said surface moisture is removed from the entire said sinter bed, and thereafter igniting a surface of said sinter bed and maintaining a controlled draft through said sinter bed of an oxygen containing gas to sustain combustion therein until a fusion zone passes entirely through said bed while avoiding packing of said bed; whereby said high gas permeability of the sinter bed

is maintained after ignition thereof and throughout the sintering operation to effect a rapid rate of sintering.

4. A process as in claim 3, wherein said heated gas is passed upwardly through said sinter bed until substantially all said surface moisture is removed from said sinter bed.

5. A process as in claim 4, wherein said sinter bed is formed of agglomerates having an average particle size of about ⅛ inch in diameter and said heated gas is passed upwardly through said sinter bed at a velocity between about 200 and 400 cu. ft. per minute for each square foot of sinter bed exposed to said heated gas to effect fluff drying of said sinter bed.

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DAVID L. RECK, *Primary Examiner.*

BENJAMIN HENKIN, *Examiner.*

C. N. LOVELL, *Assistant Examiner.*