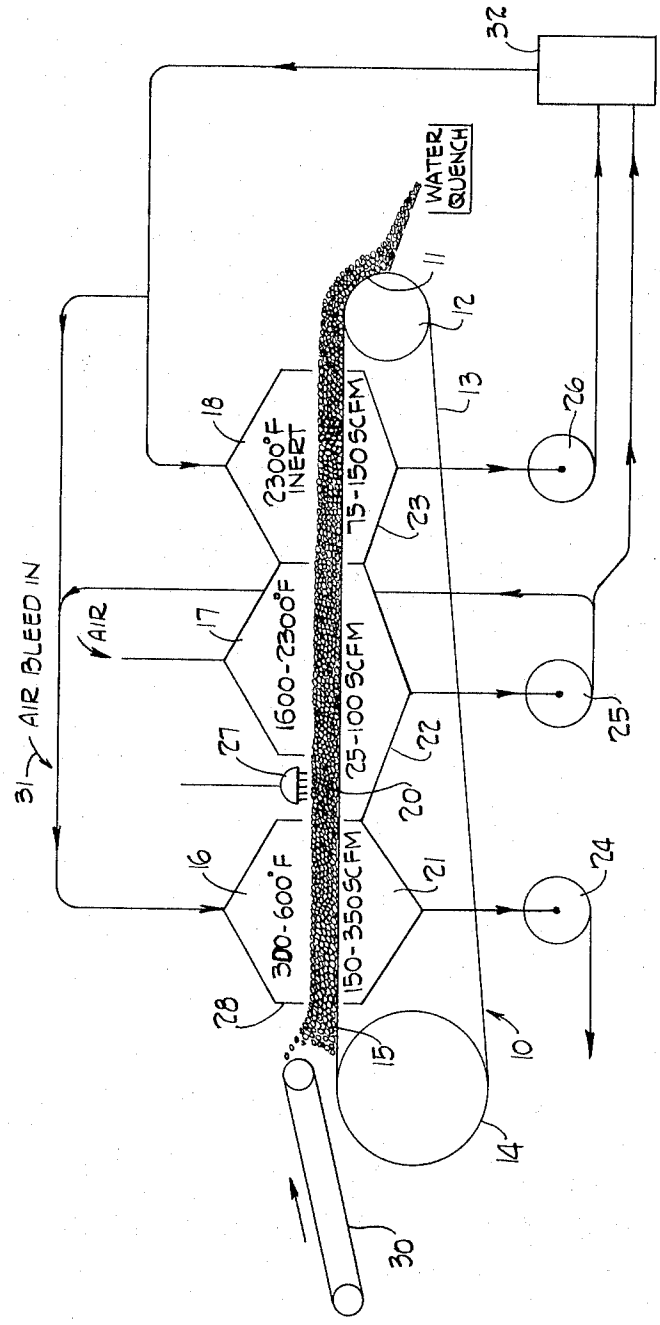
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SYSTEM FOR PRODUCING CARBONIZED AND METALLIZED IRON ORE PELLETS

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SYSTEM FOR PRODUCING CARBONIZED AND METALLIZED IRON ORE PELLETS

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This invention relates, as indicated, to an improved system for the production of carbonized iron ore pellets which have been treated further to increase the content of metal therein substantially above processes which heretofore have been practiced.

Heretofore, the practice has been to form green pellets of powdered iron ore, powered soft coal, and powdered flux in predetermined proportions, and to submit pellets having particle sizes in the range of from about ⅜ inch to 1 inch in diameter and at a bed depth of from 3 inches to 6 inches to a drying cycle followed by igniting the fuel in the pellets with a torch and subsequently passing air through the bed to effect a char-bonding of the individual pellets and a partial reduction of the metal to discrete particles of metal within the individual pellets. The extent of such reduction to metal was from 15% to about 40% by weight of the total iron in the pellet. This process is fully disclosed in the patent to Case, 2,806,779, dated September 17, 1957. The present invention is an improvement on the process of the Case patent. The pellets produced by the prior processes are weak and not able to withstand the extensive handling and transferring which modern ore treating systems now require. The present process provides pellets which are extremely hard, highly metallized, i.e., from 60% to 90% of the iron in the pellet, and thus capable of transshipment.

In the past the procedure has been to mine ore at the mine site and ship the raw ore to various smelting sites throughout the country. In view of the development of the traveling grate machines and diminishing reserves of high quality in the iron ore, two seemingly unrelated events, it is now economically desirable and feasible to produce at the mine site prereduced pellets from such ore on a traveling grate machine and to ship such prereduced pellets to smelting sites. Because of the weakness of the pellets and their inability to withstand rough handling incident to transshipment of the pellets from one point to another, there was a need for improving the pellet strength as well as to increase the extent of reduction. It has now been made possible by the improved process of the present invention that pellet strengths, which were normally of the order of 5 to 20 pounds crushing strength can now be increased to from 100 to 300 pounds crushing strength. Such levels are sufficient to permit transshipment without the formation of large quantities of fines which result from the degradation of the weaker pellets. It has also been found that the increase in strength is accompanied by further beneficial reduction.

The invention may be better understood by having reference to the annexed drawing which is a diagrammatic illustration of a conventional traveling grate machine equipped for carrying out the process of the present invention. This drawing will be explained in detail in the subsequent description, it being understood that such a drawing is merely illustrative of a preferred mode of carrying out this invention.

Briefly stated, then, the present invention is in a process of making highly metallized pellets which includes the steps of intermixing powdered iron oxide, powdered carbonaceous material and powdered fluxing material such as limestone, to form a thermally reducible solid composition. This solid composition is then pelletized with the aid of water or other suitable binding agent, for example an aqueous dispersion of clay, e.g., bentonite, which pellets in the green or moistened state have an average diameter in the range of from ⅜ inch to about 1.5 inch. The moistened pellets are charged to a traveling grate machine, such as a Dwight-Lloyd traveling grate machine to provide a burden depth of from 3 inches to 20 inches. Preheated gases are passed through the bed in a drying zone at a temperature in the range of from about 300° F. to about 600° F. The moisture content of the pellets is reduced from the initial approximately 12% by weight of water to about less than 2% of water in this drying operation. Following this step, the pellets are heated to a char-bonding temperature in the range of from about 1600° F. to about 2300°F. Such heating of the bed may be accomplished by igniting the pellets with a gas torch and drawing air through the bed either upwardly or downwardly, preferably the latter, so that the oxygen of the air can react with the carbon content of the dried pellets to form an oxide of carbon, e.g., carbon monoxide or carbon dioxide, exothermically to raise the temperature of the bed. At the same time, the volatile components of the coal are driven off, and a tarry substance, which may be asphaltic in nature, remains behind to form a relatively weak bond holding the pellets together and in discrete relation to each other. Thus, the coal which is preferably used in this process is of the soft coal type characterized by the presence of tarry residues. Up to about 40% by weight of the available iron, and more usually no more than about 20% by weight of the available iron is reduced in the carbonizing stage to discrete metallic particles, very small in size, but visible to the unaided eye. These partially reduced pellets are then submitted to the metallizing step in which the temperature of the bed is raised to as high as 2400° F., and more usually in the range of from about 2200° F. to about 2350° F. The gases which are passed through the bed in this step are relatively inert, i.e., the oxygen content has been reduced to no more than about 5% by weight. In this stage, the unburned carbon in the pellets is caused to react further with the iron oxide and effect reduction thereof to the free metal and the fusion of adjacent particles of metal to form a metal bonded pellet. These metal bonded pellets are extemely hard, resistant to shock and able to withstand pressures of from 100 to 300 pounds in terms of crushing forces. In this stage, from 60% to 90% of the total iron available is reduced to metallic iron. The gases from this metallizing step may be recycled to provide the gases for drying. Because of the high temperature of these gases, air is bled into the line to temper the gases to provide the proper drying temperature.

Referring now more particularly to the drawing, there is here shown in diagrammatic form a traveling grate machine **10** of the traveling grate type. As is well known by those skilled in the art this machine includes an elongated trackway having supported thereon on wheels a plurality of individual traveling pallets having a bottom formed of a plurality of grate bars and having upstanding side walls. When the traveling grate members are processing along a level portion of the trackway, they form a continuous channel and level grate. At the discharge extremity **11** of the level portion, the individual pallets are carried by a terminal guide curve member **12** to a return trackway **13** in an inverted position, and returned by the opposite sprocket member **14** at the charging extremity **15** to the normal upright position to repeat the cycle. The elongated straight portion of the trackway is provided with hood portions **16**, **17** and **18** surmounting the traveling pallets for the admission or removal of gases to or from the upper surface of the burden

20 carried on the pallets. In coacting relation beneath the pallets and the burden 20 are a plurality of contiguous wind boxes 21, 22 and 23 likewise adapted for the admission of gaseous material or the withdrawal of gaseous material from the burden 20. Suitable fans 24, 25 and 26 are provided for propelling the gases in a desired manner. In order to ignite the burden, there is provided a torch 27 in which natural gas or other gaseous fuel for admission with air and burned adjacent the surface of the burden 20.

In order to render the gases insert, it is preferred to recycle the gases from the wind box or boxes 23 through afterburner 32 and back into the hood 18. Such recycling conserves heat and provides an inert atmosphere which prevents further oxidation of the carbon in the pellets and reoxidation of any reduced iron. In afterburner 32, carbon monoxide and hydrocarbons may be burned by the aid of a torch in after-burner 32, or the gases may themselves be ignited by the admission of a small amount of air to convert the carbon monoxide to carbon dioxide. The use of an after-burner aids in removing tars which build up in the fans and soon render them inoperative.

As indicated above, the pelletized green or moist balls are charged to the traveling grate to a depth which ranges from about 3 inches to about 20 inches. The depth of the burden is conveniently regulated by a gate 28. The width of the pallets may be any convenient width, for example from 18 inches to as much as 72 inches.

The burden is deposited into the traveling grate machine 10 by any suitable conveying means such as conveyor 30. Conveyor 30 is in turn mounted for coaction with a supply of moist balls of the desired particle size which as indicated above may range from ⅜ of an inch to 1.5 inch in diameter. Any conventional pelletizing apparatus may be used to form the moist green pellets. Such apparatus is capable of producing pellets of remarkably uniform sizes. For the purposes of this invention pellets having a size within the range of ⅜ inch to ¾ inch are preferred.

As schematically shown in the drawing, the burden enters a drying zone in which the burden is heated by gases passed therethrough, preferably downwardly through the burden, at a temperature of from 300° F. to about 600° F. The pellets are retained within this zone for a period of about six to eight minutes, and gas is passed through the burden at a rate of from about 200 s.c.f.m. (standard cubic feet per minute per foot squared). Fan 24 coacts with wind box 21 opposite drying hood 16 and exits the moisture laden gases to the atmosphere.

In the drying operation, care must be taken that the withdrawal of water from the green pellets shall not be such that the gases are permitted to expand rapidly within the pellets thereby causing spalling. Such spalling increases the amount of fines in the process which must be recovered and recycled.

The burden then passes under a gas fired torch 27 which coacts with windbox 22 and fan 25 to draw the gas and air downwardly through the burden 20. If desired, hood 17 may be provided for further coaction with the windbox 22 for the admission of air which may under certain conditions be preheated. The gases are drawn downwardly through the bed so as to induce burning of the fuel within the burden 20 and to elevate the temperature of the bed to between 1600° F. and 2300° F. Under these conditions, a substantial portion of the carbon is burned to carbon dioxide and carbon monoxide, and the tarry residue in the coal, e.g. bituminous coal, acts as a binder for the pellet which then becomes "char-bonded." At this stage of the chemical conversion of the iron oxide, usually about 20% of the available iron in the pellet has been converted to metallic iron in the form of very small discrete particles. This effect is obtained by passing the air downwardly through the bed at a rate of from about 25 s.c.f.m. to about 100 s.c.f.m. and for a period of from 8 to 15 minutes. The higher the temperature, the lower the time.

A portion of the air exiting from the preheating zone by means of fan 25 may be recycled into the drying zone hood 16. In order to temper the temperature of the hot gases exiting from the preheating and carbonizing zone, air may be bled into the line at 31 to adjust the temperature for the drying phase to be within the range of 300° F. to 600° F.

The burden then passes from the preheating and carbonizing zone to the metallizing zone defined by hood 18 and windbox or windboxes 23. In this phase of the treatment of the pellets, reduction of the iron by means of carbon remaining in the pellet is carried out to a point where from 60% to 90% of the iron in the pellet is converted to metallic iron. Moreover, the iron and residual oxides fuse at the temperatures of the reaction and the discrete particles which would otherwise be present join to form an iron matrix for the pellet. Accordingly, these pellets which have now shrunk in size to about half to ¾ of their normal diameter emerge as extremely hard discrete highly metallized particles.

In order to effect the further reduction, the gases which are passed through the burden in either direction, and preferably downwardly, are relatively inert, that is, they contain no more than 5% to 8% oxygen on the oxidizing side and no more than 5% to 8% of carbon monoxide on the reducing side. This range is what is meant by the term "substantially inert gases." Instead of oxygen depleted air or slightly reducing flue gases, there may be used wholly inert gases such as nitrogen or carbon dioxide or mixtures thereof. For economic reasons oxygen depleted gas is preferred.

These gases are introduced to the metallizing zone hood at a temperature in the range of from about 2200° F. to 2500° F. so that the temperature of the burden is raised to approximately 2100° F. to 2300° F. The rate at which the gases are drawn through the burden by fan 26 is in the range of from 75 s.c.f.m. to 150 s.c.f.m. The retention time in this zone ranges from about 15 to about 30 minutes.

As indicated above, the pellets issuing from the discharge end 11 of the traveling grate machine 10 contain from 60% to about 90% of the iron content of the pellets as metallic iron.

Typical composition which may be treated in accordance with this process is given in the patent to Case, and need not be reproduced here. The pelletizing techniques employed for forming the green balls are conventional. The product reduced by this process may be cooled by any suitable means including passing inert cooling gases through the bed by lengthening the machine.

The pellets produced in accordance herewith have, as indicated above, a crushing strength of the range of 100 to 300 pounds and are thus quite suitable for handling in transshipment to a remote smelting site.

There has thus been provided an improved process for carbonizing and metallizing iron ore pellets to improve the crushing strength of the pellets and to provide a nearly completely reduced charge material for use in a smelting operation such as a cupola type furnace or a blast furnace. This preparation of a raw material at the mine site enables effecting of economies and avoids freight charges on large amounts of combined oxygen, and introduced into the pellet a proportion at least of the slag forming constituents which will be ultimately necessary in the formation of pig iron.

Other modes of applying the principle of this invention may be employed instead of those specifically set forth above, changes being made as regards the details herein disclosed, provided the elements set forth in any of the following claims, or the equivalent of such be employed.

It is, therefore, particularly pointed out and distinctly claimed as the invention:

1. The process of making discrete metallized pellets which includes the steps of:

(a) forming a mixture of fines of iron oxide, a carbonaceous material, and a fluxing material, the carbonaceous material containing carbon in amount sufficient to reduce 100% of the iron oxide to free metal,

(b) forming moistened pellets of said mixture having an average diameter of about −1.5, +⅜ inch,

(c) charging said moistened pellets to an endless conveyor at a depth of from 3 to 20 inches, to form a bed of moist pellets,

(d) drying said bed gases by passing preheated gases therethrough at a temperature of from about 300° F. to about 600° F.,

(e) heating said bed by passing oxidizing gas therethrough to raise the temperature of said bed to between 1000° F. and 2000° F., and

(f) subsequently heat soaking and metallizing said bed by passing non-reactive gases containing not more than 5% of oxygen by weight, through the burden to raise its temperature to a maximum of about 2400° F. for a period of time sufficient to reduce from 60% to no more than about 90% of the chemically combined iron in said mixture to metallic iron.

2. The process of making discrete metallized pellets which includes the steps of:

(a) forming a mixture of fines of iron oxide, a carbonaceous material, and a fluxing material, the carbonaceous material containing carbon in amount sufficent to reduce 100% of the iron oxide to free metal,

(b) forming moistened pellets of said mixture having an average diameter of about −1.5 inch, +⅜ inch,

(c) charging said moistened pellets to an endless conveyor at a depth of from 3 to 20 inches, to form a bed of moist pellets,

(d) drying said bed gases by passing preheated gases therethrough at a temperature of from about 300° F. to about 600° F.,

(e) heating said bed by passing oxidizing gas therethrough to raise the temperature of said bed to between about 1000° F. and 2000° F.,

(f) subsequently heat soaking and metallizing said bed by passing non-reactive gases containing not more than 5% of oxygen by weight, through the burden to raise its temperature to a maximum of about 2400° F. for a period of time sufficient to reduce from 60% to no more than about 90% of the chemically combined iron in said mixture to metallic iron, and

(g) recycling gases from said heating step to said drying step.

3. The process of making discrete metallized pellets which includes the steps of:

(a) forming a mixture of fines of iron oxide, a carbonaceous material, and a fluxing material, the carbonaceous material containing carbon in amount sufficient to reduce 100% of the iron oxide to free metal,

(b) forming moistened pellets of said mixture having an average diameter of about −1.5 inch, +⅜ inch,

(c) charging said moistened pellets to an endless conveyor at a depth of from 3 to 20 inches, to form a bed of moist pellets,

(d) drying said bed by passing recycle gases therethrough at a temperature of from about 300° F. to about 600° F.,

(e) heating said bed by passing oxidizing gases therethrough to raise the temperature of said bed to between about 1000° F. and 2000° F.,

(f) subsequently heat soaking and metallizing said bed by passing non-reactive gases containing not more than 5% of oxygen by weight, through the burden to raise its temperature to a maximum of about 2400° F. for a period of time sufficient to reduce from 60% to no more than about 90% of the chemically combined iron in said mixture to metallic iron, and

(g) cooling said metallized pellets.

4. The process of making discrete metallized pellets which includes the steps of:

(a) forming a mixture of fines of iron oxide, a carbonaceous material, and a fluxing material, the carbonaceous material containing carbon in amount sufficient to reduce 100% of the iron oxide to free metal,

(b) forming moistened pellets of said mixture having an average diameter of about −1.5 inch, +⅜ inch,

(c) charging said moistened pellets to an endless conveyor at a depth of from 3 to 20 inches, to form a bed of moist pellets,

(d) drying said bed by passing recycle gases therethrough at a temperature of from about 300° F. to about 600° F.,

(e) heating said bed by passing oxidizing gases therethrough to raise the temperature of said bed to between about 1000° F. to 2000° F.,

(f) subsequently heat soaking and metallizing said bed by passing non-reactive gases containing not more than 5% of oxygen by weight, through the burden to raise its temperature to a maximum of about 2400° F. for a period of time sufficient to reduce from 60% to no more than about 90% of the chemically combined iron in said mixture to metallic iron, and

(g) quenching said metallized pellets in water.

References Cited by the Examiner

UNITED STATES PATENTS

2,190,493	2/1940	Stehli	75—5
2,696,432	12/1954	Davis	75—5
2,750,274	6/1956	Lellep	75—5
2,758,919	8/1956	De Vaney et al.	75—5
2,806,779	9/1957	Case	75—4
3,020,147	2/1962	Boss et al.	75—5
3,093,474	6/1963	Collin	75—3

FOREIGN PATENTS

835,329	5/1960	Great Britain.

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