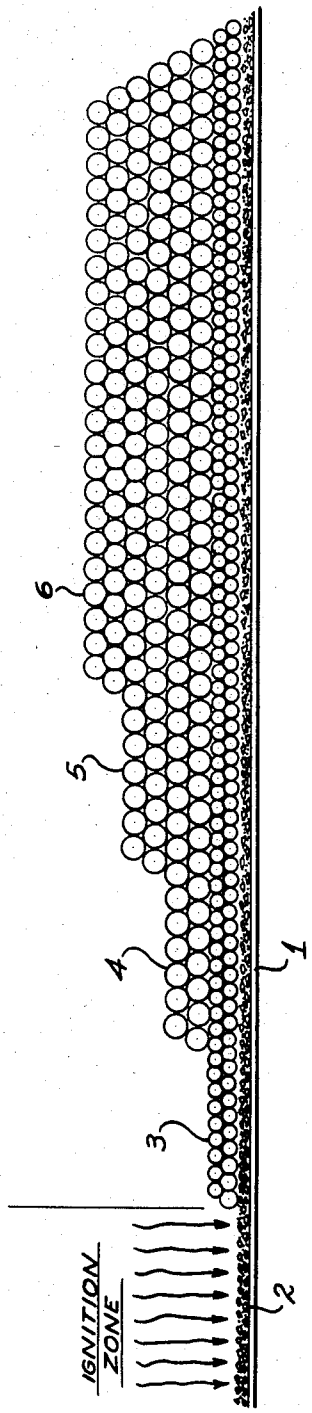
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UPDRAFT PELLETIZING METHOD

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UPDRAFT PELLETIZING METHOD

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This invention relates generally to the art of iron ore beneficiation and is particularly concerned with a method of indurating green balls of iron ore by which the yield of a statisfactorily sintered product may be increased in percentage and tonnage as compared with conventional methods.

Heretofore, green balls of iron ore ranging in size from between about —½ inch and about +⅜ inch have been regarded as best suited for firing and conversion into indurated pellets. However, only about 83 percent of the product resulting from that practice was satisfactorily indurated, the remainder being insufficiently fired cannot be classified as recoverable material, and therefore has to be recirculated. Thus the maximum possible production of satisfactory product by the standard procedure has been much lower than desired. In an effort to avoid the losses incident to such unfired agglomerates, proposals were made either to increase the amount of induration, as by increasing the amount of fuel, or by decreasing the size of the pellets. Each proposal had disadvantages which strongly militated against its adoption. Increasing the amount of fuel employed would produce additional heat and might be expected to fire all the pellets, but would increase the fuel cost and operating expenses and might result in fusing portions of the bottom layer of pellets with resultant restriction of air flow in certain areas of the pellet bed and the production of an unsatisfactory product above such areas. Decreasing the diameter of the pellets throughout the bed would increase the demand on the production capacity of the balling apparatus and the smaller pellets would tend to increase the resistance of gas flow through the bed, thus increasing the possibility of unsatisfactory firing of the pellets in the upper layers of the bed. A bed of these smaller pellets would naturally be more subject to fluidizing and "blow hole" formation.

The present invention aims to avoid these several disadvantages, and to obtain a considerably higher amount of satisfactorily indurated product. Succinctly stated, this invention is predicated on the discovery that new and surprising results may be obtained when the green balls in the firing bed are smaller in the bottom four-inch to eight-inch layer than thereabove.

Generally, in accordance with this invention, the first or lowermost layer of green balls will be no thicker than any of the upper green ball layers but in no event will any such upper layer be more than three times as thick as the first or lowermost green ball layer. This limitation is imposed by the fact that the fire can be smothered and the ascent of the induration zone arrested by excessive green ball layer depths. Addition of the green balls as successive beds in timed intervals related to the progress of the firing operation enables consistently satisfactory results where the ultimate bed depth is up to ten times that of the bottom green ball layer. The important consideration thus is the thickness or depth of the green ball burden over the induration zone

at any given time and not the depth of the indurated pellet bed after firing has been completed or at any intermediate stage of firing.

The present invention will be better understood by those skilled in the art from a consideration of the following specification and the accompanying drawing in which the figure shows diagrammatically a firing bed constructed in accordance with the present invention.

In the figure, an endless conveyor, indicated at **1**, consists of the usual grate bars which provide a support for the pellet bed. At **2** is indicated a layer of indurated pellets, solid fuel, or both, disposed on the conveyor and brought to incandescence by the direct application of a flame or by combustion of the solid fuel. Green balls of iron ore which are designated at **3** are laid down on the incandescent material **2** in the form of a layer as the conveyor moves continuously and **4**, **5**, and **6** indicate three successive layers of green iron ore pellets which are laid down successively on the previously deposited layer of pellets. Thus the figure shows a firing bed having a layer of incandescent material next to the conveyor and four separately formed layers of green balls thereabove.

In carrying out the present invention, conventional practice may be followed in many of the steps. The green balls are made by mixing fines of hematite or magnetite iron ore with other materials, such as limestone and bentonite clay, in finely divided form and with a suitable amount of water in the form of a fine spray. This mixture is subjected to the action of a balling device which will convert the mixture into balls of various sizes. Any suitable balling device or method may be used, but it is preferable to use one of the types in which a hollow member, which may be cup-shaped or semi-spherical or of any other suitable shape, is mounted for rotation about its longitudinal axis while the latter is inclined at such an angle to the vertical that the materials to be formed into balls will be rotated in the vessel and retained therein while rolling and increasing to the desired size before being discharged therefrom. We have found that the apparatus and processes disclosed and claimed in copending application Serial No. 580,423, filed February 15, 1956, can be used with good results for this purpose.

After the green iron ore balls are so formed they are preferably rolled in, and their surfaces covered by, a suitable fuel, such as finely-divided (i. e. minus 100-mesh) anthracite coal, coke breeze or the like.

Firing of the green iron ore balls as we have carried it out involves placing the balls on an incandescent bed carried by a continuously moving conveyor as set forth in detail and claimed in copending application Serial No. 587,393 filed May 25, 1956. The balls are fed onto this conveyor in successive layers and when the balls do not carry a sufficient fuel, solid fuel may be added with the balls. More in detail, a four-inch layer of minus ½-inch mesh indurated pellets is placed on the top of the grate bars. A monolayer of minus ½-inch plus 3-mesh anthracite coal is sprinkled on the layer of indurated pellets to perpetuate the incandescence. This ignition hearth layer is brought to incandescence by applying gaseous propane under a gentle downdraft. The downdraft air flow should be sufficient to remove the products of combustion from the propane gas. After ignition the propane burner is removed and updraft air is started as one eight-inch layer of green ball feed is added on top of the ignition layer. The updraft air strips the heat from the ignition layer, transfers it to the coal on the green balls which burns and starts a combustion zone to rise in the bed. The remaining three layers of green balls are added as the hot zone reaches the top of each previously fired layer. The total bed

depth at the termination of the firing cycle is 36 inches, which includes a four-inch ignition layer of previously fired pellets and 32 inches of newly-fired pellets as the active bed. The satisfactory fired product which was obtained averaged about 82.8 percent of plus 3-mesh (i. e. about ¼ inch) product and the firing capacity averaged about 6.88 long tons per square foot per day over the firing zone. Actually in this operation approximately 25.5 minutes was the time required to completely fire the 32-inch active bed, six to nine minutes being the time necessary to completely fire the first eight-inch layer and attain a temperature of 2500° F.

In contrast with the foregoing practice, the practice of the present invention and the results obtained thereby are shown by the following examples. In one form of the invention all the conditions of the foregoing illustration were kept constant except that the green balls in the bottom four inches of the active bed were of smaller size, ranging between about minus ⅜-inch and about plus 3-mesh and the thickness of the other three layers was about 9⅓ inches each. Under these conditions, the lowermost green ball layer was completely fired at a maximum temperature of 2500° F. within three to four minutes and the total active bed of 32-inch depth was similarly fired in a total of 24.5 minutes. The yield percentage of 3-mesh product averaged over 90.3 percent and the average firing capacity was about 7.77 long tons per square foot per day over the firing zone.

In another form of the invention, all the conditions of the standard practice stated above were kept constant except that all four green ball layers comprising the active bed were eight inches deep. The first or lowermost green ball layer was completely fired and the temperature had reached 2500° F. within six to ten minutes. The entire 32-inch active bed was completely fired in 25.5 minutes.

Thus it will be seen that by reducing the size of the green iron ore pellets in the bottom part of the bed the yield was sharply increased both percentagewise and in tonnage. Also it will be seen that when the thickness of this bottom layer is increased from four inches to eight inches the percentage yield is still further increased. Although the average firing capacity was slightly less than with the four-inch layer of the smaller pellets, it was considerably higher than that obtainable with the conventional practice.

The increase in the thickness of the three upper layers from about eight inches to about 9⅓ inches increased the demand on the balling apparatus which was not increased appreciably when an eight inch bottom layer of small pellets was used. Further, the possibility of blow holes in the bed was greater with the four-inch layer of small pellets than with the eight-inch layer of such pellets. For these reasons it is preferable in practicing the present invention to use an eight-inch layer of the small pellets but, as stated above, results which are not quite so good, but yet are quite superior to those obtainable by the standard practice, may be obtained by employing a four-inch layer of the small pellets.

It will be understood by those skilled in the art from the foregoing general and specific description of this invention and from the appended claims that the essential novelty of the method of this invention consists in the establishment of a first green ball layer on a traveling grate of certain depth or thickness and critical green ball size or diameter. The exclusive use of green balls of diameter between minus ⅜-inch and plus 3-mesh or plus ¼-inch in this first layer in moving firing beds made of a series of green ball layers of green balls of different sizes accounts for the new and important advantages of this invention set forth above. However, in order to obtain these advantages consistently it is necessary that the induration operation be conducted in such manner that substantially the entire green ball charge of all the layers be fired out. Thus the establishment of a firing bed and the more or less steady upward advance of a zone of induration through the green ball layers is important. At least, care should be exercised to prevent smothering of combustion in the bed or coalescence of green balls by exceeding the capacity of the equipment. Control in this respect can easily be maintained by limiting the thickness of the individual green ball layers to a certain dimension according to the capacity of the apparatus and depositing each such layer as the induration zone breaks through the top of the bed. Alternatively, the satisfactory progress of the induration zone may be assured by varying the thickness of the several green ball layers in accordance with the relative depths of the induration zone within the bed as these layers are deposited, an index such as gas temperature above the bed being used to determine the limit of the thickness of the green ball layer to be established. In any event, however, the green ball burden at any time, whether in the form of a single layer or parts of two or more separately deposited layers, should not exceed the depth which is defined in the appended claims as "induratable" and which is described above as not so great as to smother combustion in the bed or lead to coalescence of the green balls.

Having thus described this invention in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains to make and use the same, and having set forth the best mode contemplated of carrying out this invention, we state that the subject matter which we regard as being our invention is particularly pointed out and distinctly claimed in what is claimed, it being understood that equivalents or modifications of, or substitutions for, parts of the above specifically described embodiments of the invention may be made without departing from the scope of the invention as set forth in what is claimed.

What is claimed is:

1. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consisting of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameters ranging between about −⅜ inch and +¼ inch and diameters ranging between about −½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer of thickness ranging between about 4 inches and about 8 inches of solid fuel-bearing green balls of the −⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying a second layer of green balls of the −½ inch to +⅜ inch size on the first said layer, the thickness of said second layer being restricted so that the green ball burden is completely induratable, and updraft firing the green balls in the second layer when firing of the green balls in the fist layer has been completed.

2. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consisting of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameter ranging between about −⅜ inch and +¼ inch and diameters ranging between about −½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer of thickness ranging between about 4 inches and about 8 inches of solid fuel-bearing green balls of the −⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying from one to three successive layers of green balls of the −½ inch to the +⅜ inch size on the first said layer, the thickness of each successive green ball layer being restricted so that the green ball burden is at all times completely induratable, and updraft firing the green balls

in each successive layer when firing of the green balls in the next layer below has been completed.

3. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consisting of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameters ranging between about —⅜ inch and +¼ inch and diameters ranging between about —½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer about four inches thick and composed of solid fuel-bearing green balls of the —⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying a second layer consisting of green balls of the —½ inch to the +⅜ inch size on the first said layer, the thickness of said second layer being restricted so that the green ball burden is completely induratable, and updraft firing the green balls in the second layer when firing of the green balls in the first layer has been completed.

4. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consisting of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameters ranging between about —⅜ inch and +¼ and diameters ranging between about —½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer about four inches thick of solid fuel bearing green balls of the —⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying from one to three green ball layers consisting of the —½ inch to the +⅜ inch size on the first said layer, the thickness of each successive green ball layer being about 10⅜ inches and being restricted so that the green ball burden is at all stages completely induratable, and updraft firing the green balls in each successive layer when firing of the green balls in the next layer below has been completed.

5. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consisting of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameters ranging between about —⅜ inch and +¼ inch and diameters ranging between about —½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer about eight inches deep of solid fuel-bearing green balls of the —⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying from one to three successive green ball layers of the —½ inch to the +⅜ inch size on the first said layer, each successive green ball layer being about eight inches deep and being added on top of the moving bed in timed relation to upward movement of the induration zone so that the green ball burden is completely induratable, and updraft firing the green balls in each successive layer when firing of the green balls in the next lower layer has been completed.

6. The method of agglomerating finely-divided, raw, iron ore concentrates in which the major portion of the iron ore is present in the form of a compound selected from the group consistig of hematite and magnetite which comprises the steps of forming green balls of said concentrates in various sizes consisting essentially of diameters ranging between about —⅜ inch and +¼ inch and diameters ranging between about —½ inch and about +⅜ inch, making a constantly moving firing bed by establishing a first layer about eight inches deep of solid fuel-bearing green balls of the —⅜ inch to +¼ inch size on an incandescent moving bed, updraft firing the green balls in said first layer to produce indurated pellets, laying a series of three green ball layers of the —½ inch to +⅜ inch size on the first said layer, each successive green ball layer being about eight inches deep and being deposited on top of the moving burning bed when the hot zone reaches the top of the uppermost layer on the bed and updraft firing the green balls in each successive layer as a continuation of the induration process.

7. In the method of agglomerating fines of hematite and magnetite concentrates by forming green balls of said concentrates in various sizes and indurating said green balls in an updraft traveling grate furnace, the step of establishing a first green ball layer of from about 4 inches to about 8 inches thick on the grate, the green balls comprising said first layer being of diameter ranging between about —⅜ inch and about +¼ inch.

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