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APPARATUS FOR PRODUCING SPONGE IRON

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This invention relates generally to the reduction of iron oxide to produce sponge iron and to apparatus and method for carrying out the reducing reaction. The invention relates more specifically to a method and apparatus for producing sponge iron from iron-containing copper ores and particularly from copper matte that has been treated in a special way to produce an iron source material for the production of sponge iron. Although the apparatus is admirably suited to the production of sponge iron from such an iron source material produced from copper matte, it also may be used to produce sponge iron from other iron oxide source material produced in other ways.

There is now available a process for smelting copper and iron sulfides in which the matte, produced in a matte-producing furnace (such as a reverberatory) is blown in a conventional copper converter without the addition of a siliceous flux. This process produces a magma in which iron oxides predominate. This magma which has been called Ferramag is amenable to comminution and subsequent treatment in a reducing furnace with a reducing gas to produce sponge iron. In former conventional copper converter practice to produce blister copper, or the like, a siliceous flux was added to the matte in the converter and iron which was in the matte collected in the form of an iron silicate slag which was recycled to the matte-producing furnace and then ultimately transported to a waste dump. Substantially all of the iron in this slag is in the form of an iron silicate. For one reason or another this source of iron has not been used for the production of sponge iron.

According to the newer method mentioned above of operating the copper converter, which method is described in further detail in the application of Charles R. Kuzell et al., for U.S. Patent Serial No. 13,593, filed March 8, 1960, copper matte is blown in the copper converter without addition of a siliceous flux from an external source and the converter is operated preferably at a temperature in the neighborhood of 2400° F. The iron in the matte collects in a magma in the form of FeO and Fe_3O_4 and possibly other oxide of iron, with only a small amount in the form of silicate. This magma is designated by the name Ferramag. The molten Ferramag lends itself to comminution to desirable particle size by an hydraulic quenching and granulation process described and claimed in application of Charles R. Kuzell et al. for U.S. Patent Serial No. 13,589, filed March 8, 1960, now Patent No. 3,023,454. Although we prefer to produce the granulated Ferramag by the hydraulic quenching and granulation process described in that application for patent, our iron oxide reducing apparatus is suitable for the reduction to sponge iron of comminuted iron oxide produced in other ways or from other sources.

In accordance with our invention, comminuted iron oxide source material making up the charge is dried, preheated and oxidized in a suitable furnace which may, for example, be an elongated rotary furnace through which the comminuted charge is passed. The charge, preferably preheated and oxidized, is then passed into the upper end of a vertically disposed circular reducing chamber and passes downwardly therethrough. Reducing gas, preferably air-reformed natural gas within controlled

temperature limits and within a predetermined essential range composition, is passed upwardly through the downwardly passing charge and thence out of the top end of the reducing chamber. The spent gas from the reducing chamber which still retains sensible and potential heat values may be used to preheat the incoming charge or for such other purposes as desired. The reduced sponge iron product is removed from the bottom end of the reducing furnace simultaneously as new charge is introduced at its top end. A novel bottom closure for the reducing chamber, in the form of a circular table rotatable on a vertical axis, is provided at the bottom end of the reducing chamber and this rotatable table is provided with a radially disposed slot in which a grooved delivery cylinder is mounted for rotation on a horizontal axis; the grooves lying coaxially at the periphery of the delivery cylinder and extending the full radius of the reducing chamber. The delivery cylinder collects small amounts of charge in its grooves from the bottom of the column of charge in the reducing furnace as the periphery of the delivery cylinder rotates on its horizontal axis, simultaneously with the rotation of the table bottom on its vertical axis. That is, the finished sponge iron product is "nibbled" off the bottom of the pile of charge in the reduction chamber by the edges of the grooves in the rotating delivery cylinder cutting into the treated charge at the bottom of the pile causing the product to collect in these grooves in small amounts. These "grooves-full" of sponge iron product are delivered by the cylinder, as it rotates, to a sponge iron receiving trough where it may be cooled and then delivered into a chute through which it is passed into a suitable collector container.

Although the novel features which are believed to be characteristic of the invention are pointed out in the annexed claims, the invention itself as to its objects and advantages and the manner in which it may be carried out, may be better understood by reference to the following more detailed description, taken in connection with the accompanying drawings forming a part hereof, in which

FIG. 1 is a view in elevation, partly diagrammatic, of a plant for producing sponge iron from comminuted iron-oxide source material such as Ferramag, illustrating an embodiment of our invention;

FIG. 2 is a top plan view of the reducing furnace on line **2—2** of FIG. 1;

FIG. 3 is a view to larger scale, in elevation and partly in section, of the reducing furnace, showing the rotatable table bottom, rotating mechanism, delivery chute, and related parts;

FIG. 4 is a sectional view on line **4—4** of FIG. 3 but to larger scale showing the reducing gas manifold for distributing reducing gas into a charge of iron oxide in the reducing chamber;

FIG. 5 is a view on line **5—5** of FIG. 4 showing a detail;

FIG. 6 is a view on line **6—6** of FIG. 4; this is a view at right angles to FIG. 5;

FIG. 7 is a view on line **7—7** of FIG. 3, but to larger scale, showing the top of the rotatable table forming the bottom closure of the reducing furnace, and the grooved delivery cylinder mounted for rotation therein;

FIG. 8 is a view on line **8—8** of FIG. 7;

FIG. 9 is a view on line **9—9** of FIG. 8, showing the rotatable delivery cylinder and delivery chute; and

FIG. 10 is a partial view in section on line **10—10** of FIG. 3.

Referring now to the drawings in which like reference characters indicate like parts throughout the several views, an illustrative plant according to our invention for producing sponge iron from comminuted or granular iron oxide is shown generally in FIG. 1. It comprises, in