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APPARATUS AND METHOD FOR PRODUCING SPONGE IRON

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This invention relates to the production of iron in the form of sponge iron from iron oxide.

When the oxides of iron usually in comminuted form are reduced to the metallic state at temperatures below the melting point of the metal, the product is known as sponge iron. If such comminuted oxides of iron are passed through a furnace chamber in which reducing gases are fed through pipes or tuyeres entering the base of the chamber at such a rate as to maintain the solid particles in a state of suspension while reduction proceeds, the particles flow like a fluid and the process is known as reduction by fluidization.

One difficulty encountered in the gaseous reduction of iron oxides to sponge iron in the past has been due to the fact that when the material is largely reduced to metal, the metal particles tend to stick together to form a loosely adherent spongy mass. When such sticking together occurs in a fluidized bed the bed "sets," fluidization stops, the material ceases to flow out of the reduction chamber and mechanical means have to be devised for its removal.

Another drawback in gaseous reduction of iron oxides to sponge iron has been caused by difficulty in maintaining the temperature of the zone of active reduction sufficiently high for the reduction to continue to relative completion and at an economically rapid rate.

The gases which have heretofore been commonly proposed for use in the reduction of iron oxides to sponge iron are carbon monoxide (CO) and hydrogen (H_2) or mixtures of the two. If the primary source of carbon and hydrogen is in such a gas as natural gas (or any other methane gas) it has commonly been proposed to convert this gas in the presence of a catalyst with just sufficient air to form carbon monoxide, hydrogen and nitrogen. If the catalytic combustion chamber is properly constructed, a gas containing approximately one part by volume of carbon monoxide, two parts by volume of hydrogen and two parts of nitrogen with only minor fractions of carbon dioxide, water vapor and unreacted methane can be produced from the average natural gas.

Such a converted gas if introduced at sufficiently elevated temperatures into a bed of sufficiently preheated iron oxides is capable of reducing the iron to metal without introduction of heat from external sources in the reduction chamber itself. The low calorific value gases issuing from the reduction chamber can then be burned with more air to supply both the preheat necessary for the solid charge and the necessary preheat of the air used in the primary catalytic chamber.

On the other hand, if unconverted natural gas or a mixture of unconverted natural gas and a gas that has been partially converted in the reduction chamber with oxides of iron only and returned to the process for reuse, is used as the reducing agent it is necessary to add heat from external sources into the reduction chamber itself so as to maintain the temperatures necessary for reduction since the reaction is endothermic. In this cycle of reduction the gas issuing from the reduction chamber contains substantially no nitrogen and it has high calorific value. Any such issuing gas that is in excess of the amount recycled to the reduction chamber can be burned with air and used as a means of supplying the heat in the reduction chamber to supply the necessary heat for the endothermic reaction.

A method which develops efficient and economically operable means of providing continuous external heat in the reduction chamber itself and hence can use directly in the reduction chamber gases that have not previously been partially converted by the use of air in apparatus separate from the reduction chamber has certain considerable advantages. Also, in such a method there is considerable simplification of apparatus caused by elimination of the catalytic converter and direct use of natural gas as the reducing agent is possible. Moreover, although preheat of incoming charge and reducing gases is of course of economic benefit it is not essential to operation and does not have to be carried to the high temperatures and exact balance which are required for maintenance of continuous reduction when external heat is not applied within the reduction chamber itself.

My invention provides a method comprising a combination of steps and apparatus for carrying them out by which I can produce sponge iron in a fluidized bed economically and feasibly. I provide a way of preventing reduced metal particles from sticking together and losing their fluidity, and a method of introducing methane gas directly into the reduction chamber as a reducing agent as a component of the fluidizing gas, together with a method of introducing heat into the reduction chamber and keeping the fluidized mass at a sufficiently elevated temperature for the methane to act directly on iron oxide without the necessity of converting it to carbon monoxide and hydrogen outside of the reduction chamber. By the practice of the method in the apparatus provided by the invention I am able to produce sponge iron of high quality directly, economically, and with a low unit consumption of reducing gas in one continuously operating furnace unit.

Although the novel features which are believed to be characteristic of the invention will be 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 description taken in connection with the accompanying drawings forming a part hereof, in which:

Fig. 1 is a plan view and largely diagrammatic to illustrate the process and apparatus embodying the invention;

Fig. 2 is a view in elevation taken on line 2—2 of Fig. 1;

Fig. 3 is a view in elevation taken on line 3—3 of Fig. 1;

Fig. 4 is a partial view in section to larger scale of certain parts at the discharge end of the furnace;

Fig. 5 is a view in section showing a typical tuyere and connections;

Fig. 6 is a view in section showing a typical muffle and burner;

Fig. 7 is a view on line 7—7 of Fig. 6;

Fig. 8 is a view showing a seal in the roof of the furnace.

Referring now to the drawings which illustrate a plant for carrying out the process and in which like reference characters indicate similar parts throughout the several views, the reduction furnace **10** is a unit of generally rectangular shape. It comprises an outer shell **11** of suitable metal, such as sheet steel and the furnace is equipped with buck stays (not shown) as may be required for construction purposes. The inner side walls **12** and end walls **13** are made of refractory brick **14**, preferably with a slight outward arch. The outer side