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MANUFACTURE OF CHROMIUM-IRON ALLOYS.

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The present invention is a continuation in part of my copending application, Serial No. 543,084, filed March 11, 1922, and relates to the production of low-carbon chromium-iron alloys, especially chrome steels, and particularly their production directly from chrome ore by an exothermic self-propagating reaction in a combustion-heated furnace of the usual steel making type, without the necessity of application of high degree of extraneous heat, and especially without the use of an electric furnace which is at present regarded as necessary for the reduction of chromium from its ores.

In the production of low-carbon iron chromium alloys and steels from the most commonly used ore, chromite, by means of so-called metallic reducing agents, it is found necessary to supply external heat to the reduction mixture for the propagation of the reaction. This is most pronounced in the case of reduction with silicon. Owing to the refractory nature of the chromite, which is a combination of Cr_2O_3 and FeO, with certain percentages of Al_2O_3 and MgO invariably present, the reduction reaction is sluggish, evolving only a comparatively small amount of heat by the oxidization of of the silicon. It is, therefore, necessary to apply external heat, usually by electro-thermal means, to the reacting mass.

In accordance with the present invention, the necessity of this external application of heat is obviated or mitigated, by increasing the internal heat of the reaction to such an extent as to make the reaction practically self-propagating. This is accomplished by adding to the mixture of the chrome ore and the metallic reducing agent, such as silicon, a strongly oxidizing agent which will readily yield its oxygen to the metallic reducing agent, thus activating the reaction and producing sufficient heat thereby to allow the reduction reaction to proceed practically by itself, or with the help of very slight degree of extraneous heat. It is preferred to use a strongly oxidizing chromium compound as the heat-intensifying agent. Chromium trioxide (CrO_3) is the preferred chromium compound, although other highly oxygenated compounds of chromium, and particularly those in which the chromium is hexavalent, such as potassium or sodium bichromate, may be used in place of the chromium trioxide, the proportion of such compounds used being in the ratio of their oxygen content to that of chromium trioxide. The oxygenating compounds have a reaction with the reducing agent which is more strongly exothermic than that of the chrome ore. It is found that the intensifying action is proportional to the amount of chromium trioxide or other highly oxygenated compounds added. The amount of chromium trioxide added to the reaction mixture is dependent upon the amount of extraneous heat available to the reaction. A mixture of one part of chromium trioxide with two parts of chromite is able to produce a self-propagating reaction, with a silicon-reducing agent, requiring no extraneous heat whatsoever for the progress of the reaction.

Other strongly oxidizing agents which give up their oxygen readily so as to cause the reaction to be self-propagating may be used in place of the chromium trioxide, such, for example, as metallic nitrates, chlorates and peroxides. The chromium intensifying agents are, however, preferred since, after giving up their oxygen to the silicon, they leave metallic chromium which adds to the percentage of chromium in the resulting iron chromium alloy and, therefore, increases the yield of metal.

The process is preferably carried out by melting and forming a bath of steel in a furnace of the usual steel-making type, such as an open-hearth furnace. After the steel has been sufficiently refined and its carbon content brought to the requisite percentage, a mixture of chromite, chromium trioxide and silicon, either with or without a small quantity of lime and fluorspar as a flux, is charged on top of the molten bath in the furnace, either after or without removal of the slag formed during the refining of the steel. The mixture is started to react by the heat of the furnace and the molten steel bath and the reaction continues at the furnace temperature, owing to the heat generated by its own exothermicity. Depending on the amount of the chromium trioxide or other heat-intensifying agent present, the firing of the furnace can be kept at the usual steel-making rate, or slackened or entirely shut off, thus saving the fuel cost. In the hitherto known reductions of chromite by silicon, it was necessary, in order that the reaction could proceed, to apply electrical energy in an electric furnace, as the temperature necessary for reduction was high. This necessitated the application of an ex-

pensive heat energy, namely, electricity. By the application of the heat-intensifying agent, such as chromium trioxide, in the present process, the application of the expensive electrical energy is made superfluous and the reduction of chromium and production of chromium steel by direct reduction from the ore is made possible in the ordinary combustion-fired open-hearth furnace at the usual steel-making temperature of such furnace. As the operation proceeds, the slag formed can be periodically tapped and fresh portions of reduction mixture added, thus allowing the main holding capacity of the furnace to be usefully occupied by the steel content.

Owing to the fluxes present in the reduction mixture, it is possible to further refine the originally formed steel bath during the process of reduction of the chromium and its alloying into the steel bath.

Another method of procedure of producing chromium steel is as follows:

After the molten steel bath has been formed, a lime-containing slag is formed thereon, and the mixture of chromite and chromium trioxide or other heat-intensifying agent, together with or without fluxes, is incorporated into this supernatent slag layer, and a metallic reducing agent, such as silicon, is incorporated into the molten metallic steel bath. Thereupon the reaction is allowed to proceed exothermically between the reducing agent and the chromium compound, at the interface of the metal and slag layers, whereby the chromium reduced is absorbed in its nascent state evenly over the entire surface of the metal bath. Any other reducing agents, carbonaceous or metallic, that are already present in the molten steel, may also be utilized to reduce chromium oxide out of the chromite.

The reducing agent may be added along with the chromite and chromium trioxide or separately. A reducing agent, such as ferro-silicon or pig iron or carbon containing wash metal, has a specific gravity greater than that of the slag, so that even when charged as a mixture with the chromite and chromium trioxide, it will sink through the slag layer by gravity and become incorporated in the metal layer, so that the reaction will proceed between the reducing agent in the metal layer and the chromite and chromium trioxide in the slag layer.

The term silicon, as used herein, is intended to include not only a substantially pure silicon, but also silicon-bearing alloys, such for example, as ferro-silicon.

While the preferred embodiment of the process has been specifically described, it is to be understood that the process is not limited to its preferred embodiment, but may be otherwise embodied within the scope of the following claims.

I claim:

1. The process of making low-carbon chrome steel, comprising forming a bath of molten steel having a metal layer in which is incorporated a reducing agent and a slag layer in which is incorporated chrome ore and an oxidizing agent having a reaction with the reducing agent which is more strongly exothermic than that of the chrome ore in an amount sufficient to render the reducing reaction self-propagating at the temperature of the molten bath.

2. The process of making low-carbon chrome steel, comprising forming a bath of molten steel having a metal layer in which is incorporated a silicon reducing agent and a slag layer in which is incorporated chrome ore and chromium trioxide in an amount sufficient to render the silicon reducing reaction self-propagating at the temperature of the molten bath.

3. The process of making low-carbon chrome steel in a combustion-heated furnace of the open hearth type, comprising forming in the furnace a bath of molten steel having a metal layer in which is incorporated a reducing agent and a slag layer in which is incorporated chrome ore and an oxidizing agent having a reaction with the reducing agent which is more strongly exothermic than that of the chrome ore in an amount sufficient to render the reducing reaction self-propagating at the temperature of such combustion-heated furnace.

4. The process of making low-carbon chrome steel in a combustion-heated furnace of the open hearth type, comprising forming in the furnace a molten bath of steel having a metal layer in which is incorporated a silicon reducing agent and a slag layer in which is incorporated chrome ore and chromium trioxide in an amount sufficient to render the silicon reducing agent self-propagating at the temperature of such combustion-heated furnace.

In testimony whereof I have hereunto set my hand.

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