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METHOD OF LOWERING THE CARBON CONTENT OF HIGH CARBON FERROCHROMIUM

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This invention relates to a method of lowering the carbon content of high carbon ferrochromium to produce medium carbon and low carbon ferrochromiums.

An object of the invention is to provide a process for reducing the carbon analysis of high carbon ferrochromium without materially contaminating the product with foreign materials.

Another object is to provide a process for reducing the carbon content of high carbon ferrochromium in a simplified and economical manner.

Another object of the invention is to provide a method of lowering the carbon content of high carbon ferrochromium wherein no lime or similar materials are used for the purpose of keeping the charge in an open condition.

Another object of the invention is to utilize gaseous reagents in the treatment of high carbon ferrochromium for reduction of its carbon content.

The foregoing and other objects of the invention as may appear hereinafter are achieved in a method of lowering the carbon content of high carbon ferrochromium which includes comminuting high carbon ferrochromium, establishing a fluidized bed of the comminuted high carbon ferrochromium, by blowing upwardly through the bed a stream of oxidizing gas, establishing and maintaining in the fluidized bed a temperature of from 900° C. 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of the ferrochromium and to remove the carbon from the ferrochromium as an oxide of carbon, and thereafter treating the partially oxidized ferrochromium at an elevated temperature in an atmosphere of reducing gas for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to elemental metal.

The reduction step of the process preferably is conducted in a fluidized bed utilizing a reducing gas as the fluidizing medium.

A preferred oxidizing gas for employment in the oxidation step of the process is air, but substantially pure oxygen or carbon dioxide gas may also be used as well as other oxidizing gases and mixtures of such gases.

Hydrogen is a typical and preferred gas for effecting reduction in the final stage of the process. However, other reducing agents such as carbon monoxide, water gas, methane, or mixtures thereof may be employed advantageously.

For purposes of the present specification, high carbon ferrochromium is considered to contain carbon in amounts ranging from 4% to 8% in addition to its principal constituents, chromium and iron and its minor components, silicon, aluminum, calcium, magnesium and the like. Medium carbon ferrochromium contains from 1 to 4% carbon, and low carbon ferrochromium contains less than 1% carbon. A particularly desirable and valuable low carbon ferrochromium contains less than 0.10% carbon.

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The ferrochromiums defined in the immediately preceding paragraph are used as alloying materials in the production of low chromium steels and stainless steels. Since in making such steels the carbon content must be lowered to and kept within a specified and usually low range of values, it is possible to use the higher carbon-containing ferrochromiums for the production only of steels having relatively low chromium content. Where the chromium content of the steel is high, as in 18/8 chromium/nickel stainless steel, it is necessary to use ferrochromium having a very low carbon analysis as the alloying metal. Accordingly the present invention is utilized to provide ferrochromiums of reduced carbon content for use in making chromium steels having relatively high content of chromium.

In accordance with the invention, high carbon ferrochromium containing carbon in the amount of 7½%, for example, is ground in a suitable milling apparatus to provide fine ferrochromium powder. The fineness of the comminuted high carbon ferrochromium is such that about 60% of the powder will pass through a 200 mesh screen, for example.

The finely ground ferrochromium is introduced into a conventional fluid bed roaster or reactor having the usual heating or cooling devices and operated either continuously or batch-wise, in ways well known in the art. Air, or other oxidizing gas, is blown upwardly through the bed of ferrochromium in the reactor, and heating conditions are adjusted to provide the desired temperature in the fluidized bed. In accordance with the invention, the oxidizing reaction should be carried out at a temperature between 900° C. and 1400° C. The oxidizing reaction is allowed to proceed for a sufficient period of time to lower the carbon content to the preselected value. The carbon content may be reduced to about 5% with a concomitant oxidation of a substantial, though low amount of the metal constituents of the ferrochromium to form a product in which some of the metallics exist as oxides. If the oxidation reaction is allowed to proceed to the point where carbon is reduced to 2%, a larger portion of the metal of the ferrochromium is oxidized. Where extremely low carbon content, for example less than 1% carbon is achieved in the oxidation step, the metal of the ferrochromium is largely converted to metallic oxides.

Following the oxidation step, the partially oxidized ferrochromium, which then has the desired carbon content, is reduced with a gaseous reducing agent to return the metallic oxides to elemental metal. The reduction step is advantageously performed in a fluid bed reactor similar to that in which the oxidation step is carried out. Alternatively the gaseous reduction step may be performed in the same reactor. Hydrogen may be used as a fluidizing and reducing gas. Temperature conditions in the bed are maintained in the range 1000° C. to 1400° C. or somewhat higher and reduction is allowed to proceed for a time sufficient to substantially convert the metallic oxides to metal.

Although the reduction step preferably is carried out in a fluid bed reactor, it may be performed in any suitable apparatus wherein the partially oxidized ferrochromium is subjected to a reducing atmosphere at elevated temperature.

The invention will be described more particularly hereinafter with reference to the production of medium carbon ferrochromium from high carbon ferrochromium.

High carbon ferrochromium containing 50.9% chromium and 7.3% carbon is dry-ground in a ball mill to

provide a comminuted powdered ferrochromium having the following typical screen analysis:

Table I

Screen:	Distribution, per cent
+35 mesh -----	1.75
+48 mesh -----	2.50
+65 mesh -----	6.25
+100 mesh -----	8.75
+150 mesh -----	11.00
+200 mesh -----	9.75
-200 mesh -----	60.00
	100.00

A charge of the finely ground ferrochromium is placed in a fluid bed reactor equipped with a silicon carbide reaction tube having a perforated bottom for admission of fluidizing gas. Atmospheric air is admitted to the reaction tube through the perforated bottom at a rate sufficient to maintain the bed of ferrochromium particles in a fluidized condition. The temperature of the bed is raised to a suitable reaction temperature in the range of 900° C. to 1400° C. Test samples are taken from the fluidized bed at intervals and analysed for carbon. When the carbon is reduced to the desired value, the reactor is shut down and prepared for the reduction operation.

The following table shows inter alia the manner in which the carbon analysis of the ferrochromium is affected at temperatures ranging from 700° C. to 1350° C. for times up to 5¼ hours:

Table II

Sample	Treatment	Percent Cr	Percent C	Percent Si	Stack Gas Assay	
					Percent CO ₂	Percent O ₂
(1) 700° C. roast-material-----	At 700° C. for 0.66 hrs.-----	51.96	7.1	5.57	0.2	20.3
(2) 700° C. roast-material-----	At 700° C. for 2.5 hrs.-----	51.84	6.9	5.59	0.5	20.5
(3) 700° C. roast-material-----	At 700° C. for 3.5 hrs.-----	51.84	6.9	5.62	0.0	21.0
(1) 1,200° C. roast-material-----	At 1,200° C. for 0.66 hrs.-----	49.60	5.4	5.60	1.0	19.5
(2) 1,200° C. roast-material-----	At 1,200° C. for 1.66 hrs.-----	49.36	5.1	5.58	1.0	18.0
(3) 1,200° C. roast-material-----	At 1,200° C. for 3.16 hrs.-----	48.21	4.5	5.24	2.0	16.5
(4) 1,200° C. roast-material-----	At 1,200° C. for 4.66 hrs.-----	47.36	4.2	5.15	1.0	17.0
(1) 1,350° C. roast-material-----	At 1,350° C. for 1.08 hrs.-----	45.40	3.7	5.29	1.0	-----
(2) 1,350° C. roast-material-----	At 1,350° C. for 2.5 hrs.-----	44.94	3.8	4.97	1.5	16.5
(3) 1,350° C. roast-material-----	At 1,350° C. for 4.5 hrs.-----	43.37	3.4	4.84	0.5	18.5
(4) 1,350° C. roast-material-----	At 1,350° C. for 5.25 hrs.-----	42.74	3.3	3.97	0.5	18.5

From a consideration of Table II it is seen that no appreciable carbon oxidation occurs at 700° C. in 3½ hours. At 1200° C. the carbon is reduced to 5.4% in the first 0.66 hour of operation and is further reduced to 4.2% after 4.66 hours. At 1350° C. the carbon content is reduced to 3.7% in the first 1.08 hours and is further reduced to 3.3% in 5.25 hours.

The partially oxidized material prepared at 1350° C. in 5.25 hours and analyzing 42.74% Cr, 3.3% C, and 3.97% Si is heated in the fluid bed reactor under fluidizing conditions using hydrogen as the fluidizing and reducing gas at a temperature of 1300° C. for 5 hours. The reactor is shut down and cooled and the reduced product is removed. The reduced product has the following chemical analysis:

	Per cent
Cr -----	49.04
C -----	3.79
Si -----	4.55

which indicates that the oxides are substantially reduced.

From the foregoing description it will be evident that the invention is applicable to the treatment of ferrochromium containing less than about 7% C. For example, the carbon content of ferrochromium having from 1 to 4% or more of carbon may be substantially reduced following the principles set forth herein. Therefore, the term high carbon ferrochromium is used in the claims in a broad sense to include any ferrochromium metal regardless of carbon content that is amenable to reduc-

tion of its carbon content in accordance with the invention.

I claim:

1. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of oxidizing gas, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter treating said partially oxidized ferrochromium at an elevated temperature in a strongly reducing atmosphere of reducing gas for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

2. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of air, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter treating said partially oxidized ferrochromium at an elevated temperature in a strongly reducing atmosphere of hydrogen for a time sufficient

to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

3. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of oxidizing gas, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter treating said partially oxidized ferrochromium at a temperature of from 1000° C. to 1400° C. in a strongly reducing atmosphere of reducing gas for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

4. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of air, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter treating said partially oxidized ferrochromium at a temperature of from 1000° C. to 1400° C. in a strongly reducing atmosphere of hydrogen

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for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

5. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of oxidizing gas, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter establishing a fluidized bed of said partially oxidized ferrochromium by blowing upwardly through a body thereof a stream of strongly reducing gas, maintaining said fluidized bed at an elevated temperature for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

6. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of air, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter establishing a fluidized bed of said partially oxidized ferrochromium by blowing upwardly through a body thereof a stream of hydrogen, maintaining said fluidized bed at an elevated temperature for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

7. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly

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through a body thereof a stream of oxidizing gas, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter establishing a fluidized bed of said partially oxidized ferrochromium by blowing upwardly through a body thereof a stream of strongly reducing gas, maintaining said fluidized bed at a temperature of from 1000° C. to 1400° C. for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

8. A method of lowering the carbon content of high carbon ferrochromium which comprises comminuting high carbon ferrochromium, establishing a fluidized bed of said high carbon ferrochromium by blowing upwardly through a body thereof a stream of air, maintaining said fluidized bed at a temperature of from 900° C. to 1400° C. for a time sufficient to oxidize a substantial portion of the carbon and metal of said ferrochromium and to remove said carbon from said ferrochromium as an oxide of carbon, and thereafter establishing a fluidized bed of said partially oxidized ferrochromium by blowing upwardly through a body thereof a stream of hydrogen, maintaining said fluidized bed at a temperature of from 1000° C. to 1400° C. for a time sufficient to reduce a substantial portion of the metal oxide content of the ferrochromium to metal.

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