

UNITED STATES PATENT OFFICE

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REFINING PROCESS FOR PRODUCING PURE IRON

No Drawing. Application filed November 28, 1927, Serial No. 236,371, and in Germany December 14, 1926.

This invention relates to a process for producing substantially a pure iron by overblowing a previously prepared iron bath, subsequently reducing the same by means of a mixture of certain gases and finally carburizing the same by directly introducing one or more saturated hydrocarbons into the bath.

In processes for the production of steel, which are based upon the principle of a refining of the charge, mainly in blast refining processes both acid and basic and in hearth furnace processes both acid and basic, ferromanganese or other metal alloys are usually employed after the refining period for purposes of deoxydation.

These additions cause at the same time a carbonization of the bath and it is not possible to make the steel free from oxides and slag. The removal of these impurities of the bath, which remain from the solid compounds resulting from the reaction between the solid deoxidation material and the oxygen of the bath, hitherto was impossible.

The present invention has for its object a process according to which it is possible to manufacture iron and steel free from the undesirable elements phosphorus, arsenic, sulphur and the like. At the same time the metal manufactured according to the new process is free from slags inevitable when deoxidized according to the known processes and it is also like electric steel and electrolytic iron entirely safe against the risk of red-shortness, that is to say free from other oxygen-compounds.

With all processes of manufacturing steel hitherto in use the blowing and refining has not been continued to effect the complete combustion of the accompanying elements, because the longer the time of refining, the higher is the content of oxygen of the bath which again implies a greater consumption of costly ferro-alloys. At the same time the amount of the deoxidation-material used increases the amount of the oxides and slags remaining in the bath, and also the number of slag inclusions in the finished steel. Therefore, in manufacturing steel too long a refining or an overblowing is avoided. Metallurgists of repute are of the opinion that the

overblowing in order to remove completely the undesirable elements is purposeless, and that by the basic Bessemer process the content of phosphorus can only be reduced to 0.05%.

It has been noted, that the refining and blowing in the Bessemer process can without danger be carried so far that in the metal bath the carbon, phosphorus, manganese and silicon are entirely burnt up, so that the bath only contains iron and ferrous-oxide and that the dangerous ferrous-oxide can be removed by means of a gaseous deoxidation material. The complete removal of the undesirable elements (phosphorus, sulphur, arsenic and the like) and the other accompanying elements of the iron by overblowing to a sufficient extent therefore is a characteristic feature of the invention.

In the case of the acid Bessemer process whereat as is well known, phosphorus cannot be burnt and sulphur cannot be removed because the slag is acid, the initial raw material must be as free from phosphorus and sulphur as possible. The other elements for instance carbon, silicon, manganese are burnt by overblowing and finally the bath in the same way as in the basic process consists only of iron and ferrous-oxide.

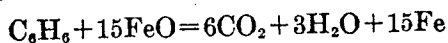
According to the laws of the chemical equilibrium it can be shown that with solid deoxidation materials which again form solid deoxidation products, a purification of the bath (deoxidation) can be carried only so far as to produce a certain concentration of the components in question present in the bath. A part of the oxygen remains dissolved in the bath and besides this oxygen, hitherto not removable by any chemical or mechanical means, there remain in the liquid steel also the foresaid residues of the solid oxygen containing compounds produced by deoxidation of the bath.

Again a further consequence from the laws of the chemical equilibrium is that it must be possible to attain a complete deoxidation by means of gaseous deoxidation material of which the reaction products with the oxygen of the bath are gaseous because

the concentration of the reaction products in the metal bath is permanently zero.

The present invention is based upon this technically important conclusion the significance of which had not up to now been understood. The bath freed from the elements accompanying the iron by overblowing which, as already mentioned, only still contains iron and ferrous-oxide is treated with a gas having a powerful reductive action. It is then impossible for oxygen bearing inclusions to remain.

It is easily to be understood that through a metal bath having a high constant of oxygen not every reducing gas can be forced. For instance vapour of benzene which indeed has a very powerful reductive action, would react with the oxygen compounds of the bath according to the following equation



that is to say that from one volume vapour of benzene in the converter would result 9 volumes of carbonic acid and steam.

This enormous increase of volume would cause an explosion and throw the bath out of the converter. An essential feature of the invention, therefore is the employment of a reducing gas burning without increase of volume. Hydrogen although it burns without increase of volume is not proper as a de-oxidation-material because its reductive action at higher temperature decreases and at the temperature of liquid iron is imperceptibly small.

It is important that the gaseous mixture introduced suffers no appreciable change in volume when burned, for while an increase causing even a mild explosion must certainly be avoided, any increase in volume would tend to disturb the nice operation of the process and form an element of danger by causing undue boiling up or splashing of the metal. When carbon monoxide is used as a reducing agent in the presence of carbon dioxide and a neutral gas such as nitrogen, the carbon dioxide quenches the tendency of the monoxide to carbonize the bath and prevents explosions, while the neutral gas serves as a diluent and volume balancing means. The desired result attained is that such a mixture burns without appreciable increase in volume, reducing the metal without carbonizing the same, and at the temperature of the iron bath, can entirely reduce the ferrous oxide present in the bath.

The task of the carbon monoxide containing gas is therefore exclusively to reduce the ferrous oxide, not to burn phosphorus, manganese or other accompanying elements which moreover have been removed by overblowing.

Of the various possible methods of manu-

facturing the pure iron, the following method has proved the best.

In the blast-box of a Bessemer converter a second gas inlet is introduced, through which a gas of the above mentioned composition can be forced into the converter.

In the manufacture of pure iron in the blast refining process a charge of pig iron of the same composition as is usually taken in the Bessemer process is refined in usual manner, except that this refining process is not broken off at the customary moment when the percentage of carbon, manganese, phosphorus and silicon has reached the amounts usual in the finished but not completely deoxidized Bessemer-steel-bath.

The refining process is carried so far that the percentage of phosphorus has sunk to less than 0.01% and the percentage of manganese and silicon amount to no more than 0.02%. In the acid process an initial raw material as pure in phosphorus and sulphur as possible is used, the process then is the same as described in the basic process.

The blast refining time must be fixed in several preliminary tests by means of chemical analysis.

At this stage the air current is cut off and the reducing gas inlet valve is opened. The reducing gas then enters the iron bath through the last-box and the tuyères. The gas current is forced through the bath till all oxygen is removed from the bath that is to say until a test piece taken out of the bath is completely free from red-shortness.

In the open hearth process the charge is also melted and refined in the usual manner and then further refined (over-fined) for a long time. The determination of whether the refining-time is sufficient is again made by means of chemical analysis. In melting and refining in the open hearth furnace the time can be worked out according to the direct (ore)—or scrap-method or according to any other method. After the refining is finished the liquid steel is brought into a converter as described above—only in this case of course the blast-inlet can be omitted—and is deoxidized by reducing gas being forced through the bath as above described.

To remove the sulphur completely the bath can be worked in the well known manner with a double slag-layer.

With regard to the phosphorus and sulphur content in the acid open hearth process it must be worked with an initial raw material as in the Bessemer process.

By the use of the new process a perfectly de-oxidized bath of pure molten iron is obtained.

The production of Siemens-Martin steel can be carried out in a similar way.

The pure iron thus obtained, which is not only characterized by its purity but also by its homogenous texture, ductility and power of

resisting corrosion, is suitable for extensive use in the technical world, and also with special advantage as a raw material for the manufacture of alloyed or unalloyed steel of any kind.

The pure iron obtained by the process above described may be recarbonized if this should be desirable. In the processes already known such recarbonization has been effected with the aid of manganese or other alloys containing a high percentage of carbon. These at the same time effect the introduction of large quantities of manganese or other metals into the steel bath, the presence of which is either undesirable or else renders the steel useless for the purpose for which it is intended.

Therefore, in the process according to this invention, the final step, namely the recarbonization is effected by means of gases or vapors having a carbonizing effect which gases are passed through the bath. It is well known that certain of the saturated hydrocarbons, commonly known as the paraffin series are more readily volatilized than others, and it is an established fact that they have a very efficient carburizing effect on the iron bath.

In said series the paraffins such as pentane and hexane are representative, being found in commercial form in petrol, benzene and the like, and mixtures thereof, and naturally, such members of the series are examples of those which may be used with the desired effect. It is of course understood that, whatever members of the series is used, the same is not normally a gas but is volatilized completely by merely introducing the same in the last step of the process.

I claim:

1. The refining process for producing iron by blast and open hearth refining methods which, after initially refining a bath of molten iron in known manner, consists of the combined sequence of steps, namely, of first overblowing the iron bath in order to introduce an excess of oxygen and thereby obtain a mixed bath of substantially pure iron and iron oxide, subsequently reducing the bath to practically pure iron by means of a non-carbonizing gas of substantially constant volume, which is actively reductive at the temperature of the bath including a mixture of carbon monoxide, carbon dioxide and nitrogen, and finally carburizing said bath by introducing a saturated hydrocarbon into the same until said bath contains a predetermined amount of carbon.

2. The refining process for producing pure iron by blast and open hearth refining methods which, after initially refining a bath of molten iron in known manner, consists of the combined sequence of steps, namely, of first overblowing the iron bath in order to introduce an excess of oxygen and thereby obtain a mixed bath of substantially pure iron and

iron oxide, and subsequently reducing the bath to practically pure iron by means of a non-carbonizing gas of substantially constant volume, which is actively reductive at the temperature of the bath including a mixture of carbon monoxide, carbon dioxide and nitrogen.

3. The refining process for producing pure iron by blast and open hearth refining methods which, after initially refining a bath of molten iron in known manner, consists of the combined sequence of steps, namely, of first forming a new slag layer upon said bath in order to protect the same, then overblowing the iron bath in order to introduce an excess of oxygen and thereby obtain a mixed bath of substantially pure iron and iron oxide, subsequently reducing the bath to practically pure iron by means of a non-carbonizing gas of substantially constant volume, which is actively reductive at the temperature of the bath including a mixture of carbon monoxide, carbon dioxide and nitrogen.

4. The refining process for producing iron by blast and open hearth refining methods which, after initially refining a bath of molten iron in known manner, consists of the combined sequence of steps, namely, of first forming a new slag layer upon said bath in order to protect the same, then overblowing the iron bath in order to introduce an excess of oxygen and thereby obtain a mixed bath of substantially pure iron and iron oxide, subsequently reducing the bath to practically pure iron by means of a non-carbonizing gas of substantially constant volume, which is actively reductive at the temperature of the bath including a mixture of carbon monoxide, carbon dioxide and nitrogen, and finally carburizing said bath by introducing a saturated hydrocarbon into the same until said bath contains a predetermined amount of carbon.

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