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METHOD FOR REFINING IRON USING TECHNICALLY PURE OYGEN

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Refining pig iron by means of technically pure oxygen makes it possible to obtain steel having a very low nitrogen content, and offers a favorable thermal balance by avoiding the heat losses which result from the passage of a large volume of nitrogen through the molten bath when refining is carried out with ordinary air or with oxygen-enriched air according to the customary processes.

However, oxygen lancing has the drawback of producing large amounts of red fumes and of causing abundant eruptions of molten metal, which may sometimes even become violent when the penetration of the oxygen jet into the metal bath is delayed by excessive thickness of the slag. Such eruptions are particularly violent when lancing is practised with a single concentrated jet, according to the usual procedure.

One object of the method according to the present invention is to suppress or to reduce iron losses and eruptions in iron converting operations using oxygen.

The novel method comprises insufflating oxygen jointly with a fluidized powdered basic reagent, such as lime and limestone, the essential novel feature being that both the oxygen and the basic reagent are insufflated into the deeper part of the molten bath, the oxygen being fed at a pressure of at least 20 kg. per square centimeter.

An advantageous embodiment of the invention uses the teachings of U.S. Patent 2,855,293, Savard and Lee, assigned to the assignee of this application. This prior patent describes how technically pure oxygen may be insufflated into a metallurgical bath in the form of one or several high-pressure thin jets. More particularly, the method according to the present invention may be practised with high-pressure injectors preferably made of copper and cooled by the expansion of the oxygen, in the manner described by the above-mentioned patent. Operating conditions may be adjusted in accordance with the teachings of the prior patent, particularly as regards the pressure and cross-section of the oxygen jets, as well as the protection of the injector by an annular sheath and the depth of the molten bath through which the oxygen is blown. More particularly, in the method of the present invention, oxygen is blown at pressures upwards of 20 kg. per sq. cm., through a plurality of orifices having an individual cross-sectional area smaller than 50 sq. millimeters, preferably smaller than 16 sq. mm., arranged in such manner that the issuing jets may traverse at least 60 cm. and preferably more than 100 cm. of molten metal. To this aim, these orifices should for instance be located in the bottom of a converter having a greater depth than usual converters of equivalent capacity.

The invention is applicable to various kinds of iron, including phosphorus- or silicon-bearing iron.

According to the preferred embodiment of the invention, the powdered basic reagent is carried as a fluid suspension in the stream of technically pure oxygen. Preferably also, this procedure is combined with injection in the form of multiple high-pressure thin jets, through the converter bottom. The fluid suspension is thus injected in such a way as to traverse a great thickness of molten iron, and to react with the iron principally in the deeper part of the bath. Thus, the reactions

are practically completed when the jets reach the bath surface, and losses of free oxygen and basic powder above the bath surface are substantially avoided, while the production of red fumes is considerably lessened or even suppressed. Also the reaction zone of the basic reagent occupies practically the same space as the oxygen reaction zone, and takes place therefore in a highly oxidizing surrounding, which increases the efficiency of phosphorus removal in the case of phosphorus-bearing iron.

The embodiment of the invention which has just been described makes it possible to avoid local overheating which is liable to cause the production of red fumes, and is detrimental to the tuyeres or injectors. In the new method, the injectors receive additional protection by the supplementary cooling effect obtained by the circulation of a relatively large mass of fluidized lime in the immediate vicinity of the injector outlet, where local overheating would otherwise more likely occur. In this respect, it is well worth remarking that methods are known for obtaining heavily laden fluid suspensions, containing for instance, by weight, two parts of lime, or even more, for every part of gas, and also that the use of very high pressures, according to the present invention, makes it possible to inject a considerable weight of fluid suspension per unit of time. Thus, there is continually maintained in the immediate vicinity of the injector outlet, a dense fluid mass in which the amount of basic powder is such as to substantially exceed the quantity consumed in the considered zone by reactions with the acidic constituents of the bath, such as phosphorus oxide and silica.

The excess of free unreacted powder lowers the local temperature. This is also a favorable factor for the removal of phosphorus. The powder also forms a very effective thermal screen between the injector tip and the surrounding zone in which exothermal reactions take place.

Injecting the basic powder in the form of a concentrated suspension in high-pressure oxygen also makes it possible to adapt the converting operation to various conditions with increased flexibility.

The penetrating effect of the pseudo-gas consisting of this suspension of powder in oxygen, will generally be very strong, owing to its high speed and density, so that a powerful stirring action may be obtained and used for homogenizing the molten bath.

This penetrating effect may be adjusted by varying the profile and length of an injector. For instance, a convergent-divergent profile may be used for obtaining a very high speed and strong penetrating effect when a very deep bath is to be treated. Conversely, the bath depth may also be correlated with the penetrating effect. Owing to the inertia of the powder, a certain distance is required for accelerating it to a high velocity. Consequently, a longer injector will produce greater penetration. A proper correlation of bath depth and penetration makes it possible to stretch the reaction zone along the greater part of the bath depth, so as to reduce or suppress the evolution of red fumes.

Further embodiments of the invention may comprise the following steps, separately or combined:

(*a*) As an additional measure for cooling the injector, carbon dioxide is added to the powder-laden oxygen stream, in an amount up to 25% by volume, so as to lower the temperature at the injector outlet by the endothermal decomposition of CO_2.

(*b*) The introduction of basic powder in the oxygen stream is continued throughout the converting operation, or at least as long as local overheating would be liable to occur. The amount of powder added may be varied during an operation, according to the effect which is desired.

(*c*) In a modified embodiment of the invention, a fraction at least of the basic powder is carried in suspension with an auxiliary fluid, which is injected in jets directed so as to intersect the oxygen jets within the molten bath. More particularly, the auxiliary fluid may be passed in heat-exchange relationship with the oxygen injector before being fed into the bath. For instance, this fluid may be passed inside a sheath surrounding an injector of the kind described in the Savard patent referred to hereinabove. Carbon dioxide is suitable as an auxiliary fluid, because its decomposition is endothermal, but air may also be used, or some other gas less reactive than pure oxygen.

(*d*) The auxiliary fluid, either powder-laden or not, is fed at a pressure lower than the oxygen pressure. The possibility is contemplated, to drive this auxiliary fluid by induction effect from an oxygen jet, so as to mix the basic powder with the oxygen.

(*e*) The basic powder is an oxide or carbonate of an alkaline or alkaline earth metal, specially lime, limestone or precipitated calcium carbonate, which may sometimes be used in addition to or as substitute for limestone, as being less abrasive. There may also be added to the basic powder reaction-promoting agents, such as fluorides.

The method of the invention may also be combined with various known metallurgical procedures, without departing from the scope of the present inventions. In such combined processes, the advantages afforded by the invention will also be beneficial. These advantages are, namely, the very effective cooling of the injectors obtained by combining the cooling effect by expansion of high-pressure oxygen with the screening effect of the powder, as well as with the removal of heat carried away by said powder. A further cooling effect is obtained when the powder is subject to endothermal decomposition, this being the case with carbonates, for instance. Finally, these cooling means may also be combined with the injection of an auxiliary gas which is first passed in contact with the outer wall of the oxygen injector. Endothermal decomposition of the auxiliary gas, such as CO_2, also cooperates.

As regards the metallurgical operation, the main advantage achieved by the invention is that the evolution of red fumes is largely avoided. Further subsidiary advantages are the possibility of keeping down the contents of the slag in iron oxide, free or combined with silicia, and, when the iron being converted contains phosphorus, its contents in lime being uncombined to phosphorus. It is contemplated that phosphate slag of suitable fertilizer grade is obtainable, in some cases without having to draw out slag until the converting operation is completed. In the case of silicon-bearing iron grades, iron losses are kept low owing to the fact that when a basic reagent is injected, silica will combine therewith more readily than with iron, thus reducing the formation of iron silicate.

What I claim is:

1. In a steel making process in which jets of technically pure oxygen are injected from below into a molten bath of iron at a high pressure of at least 20 kg. per sq. cm., the improvement which comprises simultaneously injecting from below into said bath a fluidized suspension of a powdered basic reagent selected from the group consisting of oxides and carbonates of alkaline and alkaline earth metals, and causing said reagent to mix with the oxygen in the deeper part of the bath.

2. In a steel making process in which jets of technically pure oxygen are injected solely from below into a molten bath of iron at a high pressure of at least 20 kg. per sq. cm., the improvement which comprises fluidizing in said oxygen jets a powdered basic reagent selected from the group consisting of oxides and carbonates of alkaline and alkaline earth metals.

3. A steel making process which comprises injecting solely from below into a molten bath of iron jets of technically pure oxygen carrying in suspension a powdered basic reagent, said jets being injected at a high pressure of at least 20 kg. per sq. cm., and correlating mutually the velocity of said jets with the bath depth for adjusting the extension of the reaction zone of said jets with the contents of said bath.

4. In a steel making process in which jets of technically pure oxygen are injected from below into a molten bath of iron at a high pressure of at least 20 kg. per sq. cm., simultaneously with jets of a fluidized suspension of a powdered basic reagent, the improvement which comprises suspending the basic reagent in an auxiliary gas less reactive than said technically pure oxygen and respectively injecting jets of said powder-laden gas in close proximity with oxygen jets.

5. A steel making process which comprises injecting from below into a molten bath of iron jets of technically pure oxygen at a high pressure of at least 20 kg. per sq. cm. and also injecting into said bath around each oxygen jet an annular jet of an auxiliary gas less reactive than said technically pure oxygen and carrying in suspension therein a powdered basic reagent selected from the group consisting of oxides and carbonates of alkaline and alkaline earth metals.

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