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BESSEMERIZING OF FERROUS METAL

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4 Claims. (Cl. 75-46)

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This invention relates to the bessemerizing of ferrous metal and particularly to the dephosphorizing of ferrous metal refined by the acid Bessemer process. It relates particularly to an improved method of acid bessemerizing and dephosphorizing molten ferrous metal whereby a number of important advantages are realized.

In the United States the acid Bessemer converter is used extensively for refining ferrous metal, but owing to the acid nature of the lining material and of the converter slag it is not possible to effectively dephosphorize the ferrous metal in the converter. When low phosphorus Bessemer metal is desired the metal charged into the converter is carefully selected for its low phosphorus content. The bessemerizing of the metal causes an increase in the phosphorus concentration of the metal due to the metallurgical and physical losses involved. The increase in phosphorus concentration during bessemerizing of a heat of molten ferrous metal may be as much as 10% of the original phosphorus content of the metal.

There is great demand for refined acid Bessemer metal of specific phosphorus content lower than the phosphorus content of acid Bessemer metal which can be produced by conventional procedure even with the most discriminating control of the phosphorus content of the converter charge. The satisfying of that demand is becoming more and more difficult because of the rapid diminution of the supply of iron ore of low phosphorus content.

A number of procedures for dephosphorizing acid Bessemer metal have been proposed and several have attained commercial status in the absence of the availability of better methods. In all such procedures it is necessary to effect a rather clean separation of the refined Bessemer metal from the highly acid converter slag prior to dephosphorizing. The dephosphorizing of Bessemer metal must be conducted in a basic environment, an effective dephosphorizing slag being strongly basic and also having oxidizing characteristics. Thus the metal when it is to be dephosphorized should be free of substantial amounts of acid Bessemer slag which would vitiate the dephosphorizing reaction. Dephosphorizing is effected in a receptacle into which the refined Bessemer metal is poured from the converter. As stated above it is important that the Bessemer metal when it is to be dephosphorized be free of any substantial amount of acid Bessemer slag. Dephosphorizing reagents, usually a mixture of lime, iron oxide and a fluxing compound, such as

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spar, are introduced into the dephosphorizing receptacle, ordinarily while the refined Bessemer metal is being teemed into the receptacle.

There are a number of disadvantages incident to the dephosphorizing procedures heretofore employed. It has been found that in order to provide the heat required for the dephosphorizing reaction and especially to counteract the cooling effect when cold or unfused dephosphorizing reagents are added to the metal it is necessary to carry the bessemerizing beyond the normal finishing temperature of bessemerizing in order to impart to the metal a degree of superheat, and that adversely affects the quality of the refined metal either by over-oxidizing it or by undesirably increasing its nitrogen content or both. The nitrogen content of Bessemer metal rises with increase in the maximum bessemerizing temperature.

Moreover, the oxidizing dephosphorizing slag undesirably oxidizes residual carbon and manganese which are present in the bessemerized metal before dephosphorizing. This may to some extent be compensated for by finishing the refining action in the converter somewhat younger; that is, with an additional amount of carbon and manganese to compensate for the subsequent oxidizing effect of the dephosphorizing slag, but this is not fully satisfactory because of the difficulty or virtual impossibility of controlling the degree of oxidation so that the desired ultimate characteristics of the metal are obtained.

The greater the amount of phosphorus to be removed the greater is the amount of dephosphorizing reagent which must be employed. The greater the amount of dephosphorizing reagents employed the greater is the loss of control of refined metal characteristics through the secondary oxidizing influence. This aggravation becomes so pronounced that it is not feasible to attempt to accomplish much more than about a 50% elimination of the original phosphorus, and with ever-increasing phosphorus content in Bessemer charges because of increasing scarcity of low phosphorus iron ore even a 50% elimination of phosphorus from the refined converter metal may frequently be insufficient.

I have devised a method of dephosphorizing molten Bessemer metal which has important advantages over the prior methods. I dephosphorize the Bessemer metal before completion of bessemerizing. I bessemerize ferrous metal to refine it to less than the desired ultimate extent, separate the partially refined metal from the converter slag, dephosphorize the metal and then

complete the bessemerizing thereof. I desirably bessemerize ferrous metal until the converter slag attains a nonfluid condition, tilt the converter and pour out the metal while retaining the converter slag in the converter, dephosphorize the metal and then complete the bessemerizing thereof. The completion of the bessemerizing may be accomplished in the same converter as was used for the initial bessemerizing or in a different converter. In either case both the initial and final bessemerizing is accomplished in an acid environment while the dephosphorizing is accomplished in a basic and oxidizing environment. Preferably the molten metal is first bessemerized in an acid Bessemer converter until the converter slag attains substantially its condition of least fluidity, whereupon the converter is tilted and the metal is poured out into the dephosphorizing receptacle while the converter slag is retained in the converter. Dephosphorizing reagents may be introduced into the dephosphorizing receptacle as the metal is teemed thereinto. At the end of the dephosphorizing reaction the basic dephosphorizing slag is separated from the metal and the metal is then preferably poured into a converter for completion of the bessemerizing. The bessemerizing may be completed in the same converter, which may contain the original acid converter slag or not, or in another converter.

There is a stage during the acid bessemerizing of molten ferrous metal when the converter slag attains a condition such that it will remain in the converter in contact with the converter wall and not issue from the converter with the metal being refined when the converter is tilted to pour out the metal. The converter slag forms into relatively large viscous masses which engage with the converter fall and with each other to bridge over the outflowing metal and remain in the converter. I take advantage of this change of state of the converter slag to interrupt the bessemerizing and pour the partially bessemerized metal out of the converter beneath the slag at the time when the slag by reason of its innate characteristics remains in the converter and does not issue from it along with the metal. A very clean separation between metal and converter slag can be accomplished in this way. A difficulty heretofore incident to dephosphorizing, even though the dephosphorizing was accomplished only at the end of the bessemerizing step, was the effecting in an economical manner of a clean separation between the metal and the converter slag, for any substantial amount of converter slag in the metal at the time of dephosphorizing would vitiate to a considerable extent the dephosphorizing reaction. Heretofore either the converter metal with the converter slag was poured into the dephosphorizing receptacle after which the converter slag was raked off or an attempt was made by the use of a wooden implement somewhat like a rake to hold back the converter slag and thus prevent it from issuing from the converter while the metal was being poured out, thus making it possible to introduce the dephosphorizing reagents during teeming of the metal from the converter. However, great difficulty was encountered in effectively holding back the converter slag by such means as the slag at the end of a full blow is quite fluid and tends to flow out with the metal. This difficulty I have entirely overcome by interrupting the bessemerizing at the time when the converter slag has the characteristics above described which makes it possible to pour the metal out of the

converter while the slag of its own accord remains in the converter and a clean separation is effected.

Both the chemical composition and the physical characteristics of converter slag change substantially during bessemerizing. In the early stages of the blow during the time when mainly silicon with some manganese is being eliminated the converter slag is high in iron oxide (FeO) content. The slag at this period of the blow consists of roughly equal parts of iron oxide and silica (SiO_2) and has an extremely thin and watery consistency due to the effect of the relatively high iron oxide content. Later on in the heat after some carbon has been oxidized subsequent to almost complete removal of the silicon and manganese the character of the slag markedly changes in both chemical composition and consistency. For example, about one minute after the start of the carbon eliminating period the silica content is about one-fourth more than the iron oxide content and the slag is substantially less watery or fluid. Further along during the carbon elimination period while the iron oxide content is being reduced by the carbon a gradual increase in the silica content of the refining slag occurs until the silica content becomes as much as three times the iron oxide content. This is ordinarily about one and one-half to three minutes after the start of the carbon eliminating period. At this time the slag becomes so refractory and its melting temperature becomes so high that the slag for a time practically ceases to be liquid and forms into relatively large individual viscous lumps or masses. It is at this stage that I preferably pour the metal out of the converter into the dephosphorizing receptacle, which I can do with a clean separation of metal from converter slag and without the use of any device such as a wooden rake to hold back the converter slag. The metal is so free from converter slag that the dephosphorizing reagents can be introduced during the teeming of the metal.

In a normal full blow in a Bessemer converter as the charge approaches its full blown condition, i. e., when the desired carbon elimination has been substantially completed, the proportion of iron oxide in the slag again increases and at the end of the blow the iron oxide content of the slag is about equal to the silica content and the slag again becomes thin and watery.

My process has the further advantages that dephosphorizing can be accomplished at a lower temperature than heretofore and that it is unnecessary to superheat the blown metal as above explained. Ferrous metal dephosphorizing is promoted at lower temperatures and becomes progressively more difficult as the temperature increases. With conventional dephosphorizing methods on full blown converter metal the metal temperature is at its maximum during dephosphorizing, it even being necessary to superheat the metal as explained above. If the dephosphorizing reagents are added in unfused form, i. e., relatively cold, the amount of superheat has to be even greater than otherwise in order to provide sufficient temperature in the metal to permit of its handling in subsequent operations, as, for example, pouring into ingots or admixing with iron silicate slag in the manufacture of wrought iron by the Aston process. When my above described method is employed the maximum temperature of the metal at the time of dephosphorizing can be from 200° to 300° F. lower than heretofore.

A further advantage of my process is that the

undesirable effect of secondary oxidation of elements such as carbon and manganese during dephosphorizing is greatly minimized because the metal is only partially refined when the dephosphorizing is accomplished and during the final bessemerizing step after dephosphorizing a desired degree of control can be exercised both with respect to the chemical composition of the metal and the degree of oxidation.

I mentioned above that due to the secondary oxidizing influence prevailing in conventional practice it has heretofore been difficult to accomplish substantially more than 50% phosphorus elimination without introducing undesirable complications through the more or less uncontrollable secondary oxidizing reaction. With my method any amount of dephosphorizing may be accomplished entirely free from the undesirable effects of the secondary oxidizing reaction because the dephosphorizing is effected when the metal is partially refined and the conclusion of the bessemerizing may be carried on in such fashion that the effects of any secondary oxidizing reaction during dephosphorizing are of no moment even though a most drastic dephosphorizing reaction has been effected to accomplish maximum phosphorus elimination.

While I have described certain present preferred methods of practicing the invention it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously practiced within the scope of the following claims.

I claim:

1. In the acid bessemerizing of ferrous metal, the steps of partially acid bessemerizing ferrous metal in a converter until materially less than all the constituents in the ferrous metal which are to be oxidized by bessemerizing have been oxidized, cleanly separating the partially bessemerized metal from the acid refining slag, dephosphorizing the partially bessemerized metal and thereafter completing the bessemerizing of the metal.

2. In the acid bessemerizing of ferrous metal, the steps of partially acid bessemerizing ferrous metal in a converter until materially less than all the constituents in the ferrous metal which are to be oxidized by bessemerizing have been oxidized and the acid refining slag in the converter attains substantially its least fluid condition, at that time tilting the converter and pouring out

the partially bessemerized metal while retaining the slag in the converter, dephosphorizing the partially bessemerized metal and thereafter completing the bessemerizing of the metal.

3. In the acid bessemerizing of ferrous metal, the steps of partially acid bessemerizing ferrous metal in a converter until materially less than all the constituents in the ferrous metal which are to be oxidized by bessemerizing have been oxidized and the acid refining slag in the converter attains substantially its least fluid condition, at that time tilting the converter and pouring out the partially bessemerized metal while the slag due to its relatively nonfluid condition remains in the converter and does not flow out with the metal, whereby a clean separation between the metal and slag is effected, dephosphorizing the metal while outside the converter, introducing the dephosphorized metal into a converter and by bessemerizing completing oxidizing of all the constituents in the metal which are to be oxidized by bessemerizing.

4. In the acid bessemerizing of ferrous metal, the steps of partially acid bessemerizing ferrous metal in a converter until materially less than all the constituents in the ferrous metal which are to be oxidized by bessemerizing have been oxidized and the acid refining slag in the converter has a silica content of the order of a multiple of the iron oxide content thereof and attains substantially its least fluid condition, at that time tilting the converter and pouring out the partially bessemerized metal while the slag due to its relatively nonfluid condition remains in the converter and does not flow out with the metal, dephosphorizing the metal while outside the converter, introducing the dephosphorized metal into a converter and by bessemerizing completing oxidizing of all the constituents in the metal which are to be oxidized by bessemerizing.

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The following references are of record in the file of this patent:

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Number	Name	Date
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Certificate of Correction

Patent No. 2,501,832

March 28, 1950

EDWARD B. STORY

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 38, for the word "fall" read *wall*;
and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of September, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.