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PROCESS FOR PURIFYING FERROUS METALS

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The invention relates to the removal of oxidizable impurities from ferrous metals by blowing the molten metal with an oxidizing blast, and has for its object the provision of means whereby control over the quality of the product may be greatly increased.

The method of the invention is particularly applicable to, and will be described in connection with, the manufacture of steel by processes of the Bessemer or converter type, wherein the oxidation is customarily accomplished by means of an air blast.

It is generally believed that Bessemer steel is, for some purposes, inferior in quality to steel made by other methods and that this inferiority results from characteristics inherent in the process. Chief among these characteristics are the inflexibility of the process, the great speed with which the oxidation reactions take place, variations in temperature of the bath as related to the analysis of the pig iron blown, and the uncertainty of relative rates of removal of the various impurities which are oxidized by the blast.

In the acid Bessemer process, using low phosphorus pig iron, the end point is reached very suddenly and its approach is indicated by the "drop of the flame" as the last of the carbon burns off. Since it is usual to oxidize the last 20% of the original carbon during the last minute or so of the blow, the rate of change of carbon content is very rapid and it is almost impossible to stop the blow at the correct point. For this reason it is common practice to overblow the metal and then to deoxidize it by using a relatively large amount of deoxidizer. This practice has the disadvantage, among others, of tending to produce dirty steel.

In the basic Bessemer process for converting high phosphorus pig iron, the phosphorus is largely removed after the carbon has disappeared, and for this reason the tendency to overoxidation may not be so great as in the acid process. Nevertheless, the proper end point is equally difficult to attain because there is no indicator, such as the drop of the flame, to show when the removal of phosphorus is complete.

Another inherent difficulty of the Bessemer process is that variations in temperature alter the relative rates of oxidation of impurities. Thus, with very high temperature it is possible to remove all the carbon before the silicon and manganese have been completely oxidized, and in such a case the "drop of the flame" will give an entirely erroneous idea as to the condition of the heat.

To overcome these difficulties recourse frequently is had to stopping the blow as the end point is approached and taking a coupon of metal in order to determine by inspection its approximate composition. But even this practice leaves much to be desired, for the difficulty remains of stopping the blow at exactly the right point during a necessarily short time interval.

It would therefore seem desirable to slow down the end reactions by decreasing the blast rate as the end of the blow is approached; but in the ordinary bottom blown converter this is impossible, because a high blast rate is necessary in order to prevent the metal from running through the bottom tuyères. This is, in fact, the feature of the Bessemer process, as usually carried out, which makes it so inflexible.

On the other hand, it has been proposed to increase the speed of the process and to adapt non-Bessemer pig irons to the Bessemer process by using oxygen enriched blast. Such a method of blowing obviously adds very greatly to the difficulty of properly determining the end point, by simultaneously increasing the temperature of the metal and the oxidizing power of the blast.

I have found that these difficulties can be overcome, the quality and uniformity of Bessemer steel greatly improved, and the economy and usefulness of the Bessemer process greatly enhanced, by slowing down the end reactions in a controlled manner, as hereinafter described.

According to a preferred method of the invention, the process is slowed down to the desired degree and at a desired moment by diluting the blast with an inert gas, such as nitrogen, whereby the rate of oxidation of impurities from the steel may be decreased without decreasing the blast rate. The effect of such dilution of the blast is two-fold. The rate of heat production from the exothermic reactions taking place is decreased and at the same time the large quantity of cold inert gas blown through the bath maintains the rate of removal of sensible heat. The combined effect may be so great as to rapidly cool the metal, and therefore by proper control of the oxygen content of the blast it is possible to control both the temperature of the metal and the speed with which the end point is reached.

The method is particularly advantageous in combination with the previously mentioned expedient of using oxygen enriched blast. In such a combined process, oxygenated blast may be used during the first part of the blow, whereby the reactions are carried on very rapidly and exceptionally high temperatures may be reached. The increased rate of reaction is, of course, ad-

vantageous for reasons of economy; but excessively high temperature may make it very difficult to reach the proper final analysis because of the tendency of side reactions to take place. Thus, the method of the present invention may be applied with great benefit in a combined process by reversing the character of the blast during the latter part of the blow, starting with an oxygen enriched blast and ending with a nitrogen diluted blast which permits close control of the end point.

Further advantage of such a combination process results from the fact that the two types of blast can usually be adjusted as to composition and time so that the surplus nitrogen rejected from air in producing the oxygenated blast for the first part of the blow will be balanced by the requirement for nitrogen to dilute the blast for the latter part of the blow. The total elapsed time for such a heat is considerably less than that of a heat blown throughout with ordinary air, whereby the advantages of the oxygenated blast and the diluted blast are both obtained.

It will be obvious that any gas which is in effect chemically inert under the conditions of the process, is the equivalent of nitrogen within the intent and scope of my invention.

Although for the purpose of illustration the invention has been described in connection with the Bessemer process of manufacturing steel by blowing molten pig iron with a blast of air in a bottom blown converter, many modifications and variations of the invention are possible. For example, the method may be employed for the decarburization of ferro alloys such as ferrochromium, and the blast may be applied from the side of the containing vessel, or by jets impinging upon the surface of the metal.

A modification of the invention contemplates blowing the metal at irregular intervals or in alternate cycles with gas having relatively high and relatively low oxidizing power. For example, if at any time during the blowing operation the metal becomes overheated, it may be cooled off to any desired extent by blowing with blast of decreased oxidizing power for a suitable period of time. Similarly, if the metal cools off too rapidly during the finishing blow with blast of decreased oxidizing power, it may be reheated by blowing for a suitable period of time with a blast of the usual oxidizing power, whereupon the use of diluted blast may be resumed.

The process of the invention, as has been stated, is directed particularly to the purification of ferrous metals, but it may also be applied in processes of analogous character for the removal of oxidizable impurities from nonferrous metals, as for example in the Bessemerization of copper.

I claim:

1. In a process of the Bessemer type for the decarburization of ferroalloys, the method which comprises blowing the bath of molten metal first with a blast of oxygen enriched air until a major portion of the oxidizable impurities has thereby been removed from the metal and subsequently with a blast of nitrogen-enriched air until removal of the oxidizable impurities to the desired amount has been completed.

2. Process which comprises separating air into a nitrogen-rich fraction and an oxygen-rich fraction; storing said fractions separately; withdrawing said nitrogen-rich fraction and mixing it with air to produce nitrogen-diluted air; subjecting a bath of molten metal containing oxidizable impurities to a blast of said oxygen-rich fraction until a major portion of the oxidizable impurities has thereby been removed from the metal and thereafter subjecting the bath of molten metal to a blast of said nitrogen-diluted air until purification of the metal is completed to a desired degree; and controlling the air fractionation step of the process to separate the air into oxygen-rich and nitrogen-rich fractions in the proportions required in the metal purification step of the process.

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