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PROCESS OF MAKING BESSEMER STEEL

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This invention relates to a novel method of producing steel by the Bessemer process and particularly to that part of the process that has to do with the removal or elimination by oxidation of those elements or ingredients of pig iron, scrap or other charge constituents which it is desired to remove.

The more important objects of the invention are to provide an improvement in the method whereby the Bessemer heat may be finished to a point of very low content of the elements which it is desired to remove without danger of over-oxidizing the iron; to accomplish this result by a continuation of the blow under controlled conditions of rates of oxidation of the various ingredients to be eliminated; and to safeguard the bath toward the end point of purification by the use of an oxidizable ingredient, naturally present in or purposely added to the bath, having under the controlled conditions, a relative affinity for oxygen which causes it to react after ingredients such as silicon, manganese and carbon have reacted, but having an affinity greater than the affinity of oxygen for iron and therefore minimizing the formation of iron oxide. This oxidizable ingredient may have the capacity of becoming stabilized or fixed in the slag and thus withdrawn from the bath; for instance a slag formed by combining metals or alloys of metals of the alkali, or alkali-earth group of metals or compounds or mixtures thereof with slag-forming materials.

In the ordinary American or acid Bessemer blow, there is a definite order of elimination of the silicon, manganese and carbon. When the converter is charged and turned up, the relative affinity of the elements for oxygen, at the initial temperature ordinarily employed, is such that silicon and manganese are oxidized in the early part of the blow. During the oxidation of the silicon and manganese the temperature rises in the converter, the heat being furnished principally by the oxidation of the silicon but assisted in some measure by the oxidation of the manganese. When the silicon and manganese are no longer present to protect the carbon, the blast actively begins to oxidize the carbon which had previously been protected by the silicon and manganese. The carbon burns rapidly with the production of gas which is liberated from the bath. As there is normally no excess oxygen inside the converter, this gas is mostly carbon monoxide along with the nitrogen contained in the air blast. When it reaches the throat of the converter and meets the oxygen of the air, it burns to carbon dioxide. A long flame of burning gas shoots from the throat of the converter and continues as long as carbon monoxide is provided, and the carbon monoxide in turn comes from burning the carbon of the bath. Hence, when the flame drops, it may be taken to indicate that the carbon content of the metal has been reduced to a low figure. If, after this point in the blow is reached, it is desirable to make metal of the lowest possible carbon content, I have discovered and hereinafter set forth a definite procedure by which it can be done. At no instant during the blow has the metal bath attained chemical equilibrium. It has only tended to approach equilibrium. To eliminate the last small amount of carbon from the bath it is necessary to blow into the converter some excess of oxygen over the amount theoretically required to burn all the carbon. Heretofore when making low carbon Bessemer heats, there never could be certainty as to the point at which oxidation in the converter should end and the converter be turned down. On the one hand, if turned down too soon the carbon remaining was too high, and on the other hand, if turned down too late the bath might be saturated with oxide and carry dissolved oxygen, and the blow would have to be scrapped. The problem up to now is how to finish a Bessemer heat, blown to minimum carbon and at the same time prevent over-oxidation of the product.

The present invention is based on the existing knowledge that whereas the silicon, manganese and carbon of the molten bath are removed during the blow, at the end of the blow when the converter is turned down and the de-oxidizer and re-carburizer are added, the phosphorus is found in the metal in the same quantity as in the converter charge; that is to say, none of the phosphorus is eliminated; and upon my discovery that phosphorus has a very active part in the acid Bessemer process. Its presence at the beginning of the blow, at the end of the blow, and in the steel when poured has heretofore led to the untenable conclusion that phosphorus plays no active or significant part in the process. What I have discovered is to the contrary, and the fact that gives rise to the present invention is that phosphorus is very active during the blow and particularly at the end thereof when the carbon is substantially eliminated from the molten metal; and I have discovered that if the presence of phosphorus in proper proportion is insured in the bath, either in the original charge or by later addition, a further controlled addition of oxygen to the bath may be resorted to without danger of over-oxidizing the metal. The presence of the phosphorus will protect the iron of the molten bath from excessive oxidation by combining with the oxygen. This protection will continue so long as any un-oxidized phosphorus remains in the metal at the end of the blow. Failure to recognize these facts in the past has probably been due to the uniform and homogeneous dissemination of the oxidized phosphorus through the mass of blown metal and lack of segregation or separa-

tion from the metal in any way, so that a sample of blown metal taken at the time of the turn down, would show, on analysis, all the phosphorus originally present, to remain in the metal.

If, now, it were decided to make Bessemer steel on a specification where there was no reason for reducing the initial phosphorus content of the metal, when the converter charge had been blown down to minimum carbon as above described and the excess oxygen of the air blast beyond that which was necessary to do this was taken up by the phosphorus, the blown metal on the turn down of the converter could be poured into a ladle. The oxidized phosphorus which formed during the blow is now disseminated through the bath. It is unstable in contact with silicon, manganese or carbon, and when these substances are added in the re-carburizer they reduce the oxidized phosphorus in the metal bath which has been protected from over-oxidation by the phosphorus.

The procedure above outlined is what would be followed if low carbon steel were made without any attempt to decrease the original phosphorus in any way. In the process outlined above which is made possible by my discovery of the protection from over-oxidation afforded the metal bath by the presence of phosphorus, the sequence of the blow is described. It is shown that the low carbon heats can be made and the bath protected from oxidation by the phosphorus present forming an oxidized phosphorus compound, and that this protective effect of the phosphorus will continue until nearly all the phosphorus is oxidized, the small amount of phosphorus purposely left in the bath preventing the over-oxidation of the bath.

If it be desirable for any reason to decrease the phosphorus in the molten bath, I have discovered that the oxidized compound of phosphorus which is relatively unstable in the presence of silicon, manganese and carbon, can be made stable by the addition of a metal or alloy of the alkali metals, or of the alkali-earth metals, or by compounds of any of these metals or by mixtures of any of them or their alloys or compounds. As an illustration, metallic calcium or ferro calcium or compounds of calcium, such as calcium chloride, calcium fluoride or mixtures of these substances, can be employed. The addition of these phosphorus stabilizing substances can be made in the converter immediately prior to the turn down, or in the ladle into which the blown metal is poured. The pouring should be done in such a way as to hinder or prevent the converter slag from following the metal into the ladle. The phosphorus stabilizing additions when made will form a phosphate which by itself or in combination with excess of the basic additions, will rise to the surface of the metal as a slag and be removed. This phosphorus stabilizer will make a stable compound with the phosphorus and the stabilized phosphorus compound can be diluted with some material to form, with it, a fusible slag of sufficient volume to separate quickly from the metal. There is no reaction that takes place under the outlined practice that would prevent the removal of phosphorus in this way in the ordinary acid-lined converter.

As a result of my discovery of the method of decreasing phosphorus content in an American or acid Bessemer blow, it follows that the maximum phosphorus limits on Bessemer ores which can be treated by American or acid Bessemer process can be raised by the amount of phosphorus which is removed.

To carry out the process disclosed herein Bessemer converters such as are now ordinarily used in the production of Bessemer steel can be employed. The whole Bessemer production unit, converter and blower, are calibrated so that the rate of reaction or of oxygen consumption is actually and accurately known under the varying conditions such as analysis of charge, temperature of the charge at the beginning of the blow, the temperature of the converter at the beginning of the blow and the characteristics of the air blown into the converter. When, for illustration, employing pig iron charges that have been brought to a proper standardized temperature, and with the blast corrected for atmospheric conditions, the time and the corrected air volume that is necessary to eliminate silicon, manganese and carbon may be accurately determined for the equipment in use; and when the silicon, manganese and carbon have been so eliminated as determined by the volume of the air blown in or by the drop of the carbon flame, a regulated, predetermined amount of blast can be introduced to diminish the carbon still further carrying this to the point where some of the phosphorus is oxidized but still allowing enough phosphorus to remain un-oxidized in the bath to prevent the over-oxidation of the iron.

This oxidized phosphorus may or may not be stabilized and removed from the charge as desired.

My discovery of the method of protecting the metal bath from over-oxidation during the Bessemer process, by employing phosphorus to take up and combine with the excess oxygen which is necessarily blown into the converter to completely oxidize the carbon, has made possible the manufacture of a new and useful material which heretofore it has not been possible to make.

This new material consists essentially of substantially pure iron with very little or no content of silicon, manganese, carbon or other oxidizable material which it is desired to eliminate. This new material can be made by the methods detailed herein, using phosphorus to protect the metal bath from over-oxidation, the product containing practically no silicon, manganese or carbon and with only sufficient phosphorus left in the metal to prevent over-oxidation of the bath.

Such a metal in a typical case, where it is produced with apparatus of approved form, would have approximately the formula—iron 99.8%; phosphorus .03%; and other ingredients existing in the proportions of mere traces, for instance, carbon .01%; silicon .01%; neglecting the sulphur brought in by the original charge.

I claim:

1. In the Bessemer process of producing steel, the improvement which consists in eliminating, in an acid lined converter, by oxidizing blast, elements more readily oxidizable than iron and substantially to the end points of said elements, insuring the presence of an iron-protecting proportion of phosphorus at least while attaining the end point of said elimination, and then reacting upon and eliminating the protective proportion of phosphorus by the addition of alkaline earth or alkali metal, or compounds of such earth and metal, to the bath and reacting the same with the oxidizing components then present in the molten bath.

2. A process as described in claim 1, in which the last-named step is performed in the ladle.

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