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# METHOD OF MAKING STEEL WITH A LOW NITROGEN CONTENT BY THE CONVERTER PROCESS

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The importance of a low nitrogen content in basic Bessemer steel is well known and, therefore, many suggestions have been advanced as to the production of such steel, which, however, have not resulted in a satisfactory solution of the problem.

It is, therefore, an object of this invention to provide a simplified satisfactory method of making steel low in nitrogen while applying the blast refining method.

It is another object of this invention to provide a method of making steel with a low nitrogen content, which will allow the processing of pig iron with a silicon content of more than 0.5%.

These and other objects and advantages of the invention will appear more clearly from the following specification setting forth the invention in detail.

According to the invention, steel low in nitrogen is obtained, even with a normal blowing process, by blowing oxygen or air enriched with oxygen, or oxygen yielding gas into the molten pig iron before it is poured into the converter and by continuing this blowing process until the silicon content of the pig iron has been considerably reduced.

The invention also makes it possible to overcome difficulties which have been known to steel workers since the converter process came into large-scale use and which arise in the processing of basic Bessemer pig iron with unfavorable physical and chemical properties. The demand for a hot pig iron has been raised so frequently that as a result thereof the majority of the heretofore advanced suggestions to this end have been directed to increasing the heat physically or chemically. The majority of the suggestions advanced to increase the physical heat content of basic Bessemer pig iron intends to avoid heat losses by, for example, shortening the transport distance, heating the ladles and mixers, shortening the pouring spouts, etc. As the Bessemer steel practice has proved, outstanding results can hardly be obtained in this way. Consequently, the possibility of increasing the temperature by means of the chemical properties is of greatest importance. It is known that iron and the elements accompanying the same such as carbon, silicon, manganese, and phosphorus are all adapted to act as carrier of the heat freed during the blowing process. The permissible quantity or percentage of these elements—other than iron—in pig iron is, however, limited partly for natural and partly for economic reasons. This applies particularly to the silicon content which could bring about the rise in temperature desired at the very beginning of the blowing process, but which, when amounting to more than 0.50%, leads to difficulties in the blowing process, i. e., a poor uptake of air by the converter charge, irregular blowing, and increased throw-out of metal as well as an increase in the blowing time. Therefore, it has for a long time been attempted to keep the silicon content as low as possible in order to obtain an undisturbed blowing operation and a short blowing period. The production of pig iron in a blast furnace is, however, materially facilitated both for economic and technical reasons if the furnace can deliver to the steel works pig iron with a silicon content above 0.50%.

The invention renders it possible to reconcile the conflict between the requirements to be met when making pig iron, i. e. the requirements of the blast furnace, with



the requirements of the user of the pig iron, the basic Bessemer steel producer.

It has been proved by tests carried out on a large scale with the use of a pipe for introducing the blast, that by the pre-treatment of the pig iron, e. g. in transport or storage containers, a silicon content of about 0.5 to 1% may be reduced to less than 0.15%. The basic Bessemer steel plant therefore receives a pig iron low in silicon at an increased temperature as cannot be delivered by a blast furnace without such intervening treatment. During the blowing in the converter the success of the pre-refining step becomes evident in an almost ideal blowing procedure, i. e. very short blowing period, less throw-out from the converter and, as a very important advantage, an increase in the capacity of the converter to an extent heretofore considered impossible. For example, up to 35 tons of pig iron pre-treated in this way can be charged into a normal 20 ton converter and blown to basic Bessemer steel of good quality without the yield being reduced.

The pre-treatment of pig iron can take place wherever desired between the blast furnace outlet and the converter. Naturally, the pre-treatment of the pig iron may, if need should occur, also be carried out in a converter without the addition of materials necessary for slag reaction in the normal converter process.

If the silicon content of the pig iron, before the pig iron is charged into the converter, has been reduced below 0.15%, steel with a remarkably small nitrogen content can be obtained. In part, these advantages result not only from the fact that the silicon content is very much reduced but also from the fact that by the pre-treatment the temperature of the pig iron has been raised. With the blast furnace, the process according to the invention yields the advantage that it is not any longer necessary to operate at high cost in order to be able to produce low-silicon white pig iron but that it is now possible in a materially more economic way to produce basic Bessemer pig iron with a high silicon content and to use it for the converter method. Due to the high silicon content which, with the method according to the invention, is permissible in the pig iron coming from the blast furnace, lime or similar materials suitable for binding the silicic acid may be added to the slag formed during the pre-treatment. These materials may be introduced in powder or granular form and blown together with the blast into the pig iron bath in order continuously to maintain the ability of the formed slag to bind the burned silicon of the pig iron. A further result of the pre-treatment of the pig iron with oxygen consists in a reduction of the manganese content which unavoidably occurs with the slagging off of the silicon. This is counterbalanced by the advantage of a reduction in the sulfur content. Thus, in the finished steel even lower sulfur contents can be obtained than with the customary desulphurization in the transport container or mixer.

The following numerical examples show the composition and temperature of normal basic Bessemer pig iron in comparison with pig iron treated according to the present invention:

| | Normal pig iron | Pig iron with higher silicon content | |
|---|---|---|---|
| | | Before pre-treatment | After pre-treatment |
| C ---------- percent | 3.60 | 3.56 | 3.52 |
| Si ---------- do | 0.35 | 0.61 | 0.13 |
| Mn ---------- do | 1.27 | 1.40 | 0.93 |
| P ---------- do | 1.70 | 1.74 | 1.68 |
| S ---------- do | 0.060 | 0.048 | 0.032 |
| Temperature in degrees centigrade | 1,200 | 1,220 | 1,260 |

The differences in the analyses show the advantage for the blast furnace operator. The increased silicon content in the pig iron tapped from the blast furnace at the same time means a higher Mn burden yield from the blast furnace burden and a lower sulfur content in the pig iron. Particular advantages for the basic Bessemer process lie in the higher final temperature of the pig iron and the improving and equalizing action of the pre-treatment of pig iron with oxygen whereby an always uniform and a better material for introduction into the converter is obtained. Another advantage consists in that the steel worker is now independent of the troublesome variations in the physical and chemical heat content which heretofore had to be taken into consideration.

The raising of the final temperature of the pig iron makes it possible to maintain the phosphorus content of the pig iron lower than was heretofore required. As a result thereof, not only is the need reduced for phosphorus containing additions—phosphates—in the blast furnace burden whereby a great saving is obtained, but also the dephosphorization period is shortened and the possibility of nitrogen being absorbed during the converter process is further reduced. By no means the least value of the process according to the present invention therefore consists in the low nitrogen content of the steel obtained, as will be evident from the following numerical example:

*Nitrogen content*

| Pig Iron | | Finished Steel, percent |
|---|---|---|
| Before Pre-treatment, percent | After Pre-treatment, percent | |
| 0.009 | 0.006 | 0.006 |

This qualitative result of the process becomes particularly evident when also the refining process in the converter is carried out with gaseous oxidizing means, i. e. with oxygen, or air enriched with oxygen, or other oxidizing gases. Large scale tests have shown that by the pre-treatment of pig iron according to the invention, the production of almost nitrogen-free steel is possible, i. e. a steel with a nitrogen content below approximately 0.004%. Whilst with the normal process, silicon-rich pig iron must be blown for a long time in order to obtain hot readily castable steel and consequently such steel has a high nitrogen content, it is possible according to the invention, during the blowing still further to reduce the nitrogen content of the pig iron already reduced by the treatment with oxygen, as will become evident from the following example:

*Nitrogen content*

| Pig Iron | | Finished Steel, percent |
|---|---|---|
| Before Pre-treatment, percent | After Pre-treatment, percent | |
| 0.0104 | 0.006 | 0.0028 |

With the process according to the invention, the fact that silicon rich pig iron itself happens to have a low nitrogen content can particularly advantageously be made use of.



Finally the advantage of the process of the invention becomes apparent even when blowing molten acid pig iron with a high silicon and sulfur content. If such a pig iron is pre-treated according to the invention and then desulphurized with soda, the desulphurization process calculated on the quality of soda added is more effective. Smaller quantities of soda not only involve a saving in cost but also result in the temperature of the pig iron remaining higher, and the above described advantages of the higher final temperature of the pig iron being obtained.

The above test results relate to the use of the process according to the invention in refining in a basic Bessemer converter, but the process according to the invention may also be practiced in an acid Bessemer converter. The advantage of the use of the pre-refined acid Bessemer pig iron for the manufacture of converter steel lies above all in the fact that the increase in the nitrogen content, which normally occurs prematurely during the decarburization with the customary blowing with air is avoided. It is thus possible also in a large converter with air blown through the bottom thereof to make acid Bessemer steel with very low nitrogen contents whilst using the short blowing periods customary with this type of converter.

What I claim is:

1. A method of making steel with a low nitrogen content by applying the converter process, which includes the steps of blowing a gaseous oxidizing agent with a considerable higher oxygen concentration than in ordinary air into molten pig iron prior to charging said molten pig iron into a basic Bessemer converter, continuing said blowing until the silicon content of said pig iron has been materially reduced thereby pre-refining said pig iron, charging the thus pre-refined pig iron into a basic Bessemer converter, and completing the refining process by blowing a gaseous oxidizing agent through said pre-refined pig iron in said basic Bessemer converter.

2. A method according to claim 1, in which the blast during the pre-refining of said pig iron is continued until the silicon content of the pig iron has been reduced to below 0.20%.

3. A method according to claim 1, in which the blast during the pre-refining of the pig iron is continued until the silicon content of the pig iron has been reduced to below 0.15%.

4. A method of making steel with a low nitrogen content by applying the converter process, which includes the steps of blowing a gaseous oxidizing agent with an oxygen concentration considerably higher than the oxygen concentration in ordinary air into molten pig iron having a silicon content of more than 0.5% until the silicon content of the pig iron has been reduced to less than 0.35% to thereby pre-refine said pig iron, charging the thus pre-refined pig iron into a basic Bessemer converter, and completing the refining process by blowing the pre-refined pig iron in said basic Bessemer converter with ordinary air.

**References Cited in the file of this patent**

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,709,389 | Davis | Apr. 16, 1929 |
| 2,490,990 | Work et al. | Dec. 13, 1949 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 591 | Great Britain | of 1879 |
| 2,162 | Great Britain | of 1879 |