

2,853,377

## TWO STEP REFINING PROCESS IN A TILTABLE ROTARY FURNACE

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The invention relates to the refining of pig iron and similar alloys by free oxygen and more particularly to refining molten pig iron or other alloyed or unalloyed iron containing carbon in a furnace rotatable about an axis of rotation by blowing with a gas containing at least 40% oxygen, such as oxygen gas or air enriched in oxygen.

It is an object of the invention to provide means for carrying out the refining process at a relatively low speed of rotation. Another object is to make feasible to use a higher degree of filling of the furnace than is possible in ordinary rotary furnaces. Further objects will be clear to those skilled in the art from the following description.

In the U. S. patent specification No. 2,598,393 a method is described for refining pig iron in a rotating furnace by blowing oxygen or air enriched in oxygen to an oxygen percentage of at least 40% into the furnace. It is characteristic for this method that the necessary bath movement is essentially obtained independently of the gas supply. This is contrary to the conditions in other quick-refining processes where the bath movement is connected with the gas supply and ceases entirely when the latter is stopped. This is, for instance, the case in the common acid and basic Bessemer processes as well as in the so called LD-process, where the refining takes place with pure oxygen gas which is blown vertically against the bath in a stationary converter.

When a stationary furnace is used and the oxygen gas is blown in from above the bath movement is relatively insignificant in the beginning of the process, as long as the pig iron contains a material amount of silicon, and also in the later stages of the process, particularly in refining pig iron rich in phosphorous. During that phase of the process where the carbon refining is vivid the boiling causes, however, a violent stirring which is important for the proceeding of the reactions.

If the process is carried out in a rotary furnace a vivid bath movement can be obtained during the entire process. Hereby the reactions between the metal bath and the slag bath take place more rapidly and more completely. This makes it possible, i. e., to reduce the iron percentage in the final slag and thereby in an essential degree to increase the metallic iron yield. By the rotation it is, furthermore, possible to obtain a sufficient contact between the oxygen and the bath without having to blow the oxygen onto or into the bath at a high super pressure, which is necessary with a stationary furnace. The oxygen twyer need neither be directed against the bath. In this manner the oxygen gas will to a certain extent be mixed with the furnace gases before it reaches the bath and the contact with the latter will be spread over a relatively great surface. Hereby the considerable gasification of, particularly, iron and manganese is reduced, which gasification arises at the strongly localized supply of oxygen which is unavoidable in stationary furnaces and causes great losses of iron by the escaping gases whereby an extremely annoying smoke is formed.

In order that a sufficient bath movement shall be at-

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tained in the rotary furnace a relatively high speed of rotation is suitable, however, it should be possible to increase this speed up to 30 to 40 revolutions per minute in cases where a particularly strong stirring is desired. During certain periods of the blowing and particularly when the carbon refining is most vivid and contributes to the stirring it has appeared, however, that the speed can without disadvantage be lowered considerably.

The possibility of running the furnace with a lower velocity at those occasions during the process when this is possible without disadvantage from a metallurgical point of view should be made use of as, thereby, amongst other things a considerably increased life of the lining of the converter can be attained. It would seem, namely, that at least under certain circumstances a shortened life of the lining is to be reckoned with at increased speed of rotation.

The present invention involves a further development of the art referred to and it comprises an improved method as well as a furnace for carrying out such method. According to the new method the blowing with the oxygen containing gas is performed during at least one portion of the process with the furnace rotating with its axis of rotation horizontal or inclined, suitably not more than 45°, the oxygen containing gas being introduced through a central opening of the one end wall of the furnace, and during at least another portion of the process with its axis of rotation in vertical or approximately vertical position, the oxygen containing gas being supplied to the bath from above. The method can with advantage be carried out in a furnace comprising a refractory drum having two opposite ends, one being closed and the other having an opening, said drum being rotatable about an axis of rotation passing through said closed end and said opening, means for suspending said drum swingably so that said axis of rotation can be altered from a substantially horizontal or inclined position to a substantially vertical position, means being provided for rotating the furnace about the axis of rotation at least in said substantially horizontal or inclined position. The furnace may be made swingable by supporting it together with the driving machinery on trunnions. When the drum is raised in a vertical position the rotation has only a relatively low stirring effect. Therefore the blowing can take place with equally good result with a stationary furnace, that is to say according to the principle of the LD-process.

Thomas pig iron or other pig iron with a phosphorous percentage of, for instance, 0.5% or more can be blown in a furnace equipment of this kind, for instance according to the following example.

After the furnace has been charged with 30 tons (metric) of molten ordinary Thomas pig iron containing 0.5% Si, 2.0% P and 1.0% Mn, and 3000 kgms. of lime and 2500 kgms. of ore have been added as cooling medium, oxygen gas is blown into the furnace for approximately 15 minutes with the latter in an approximately horizontal position with the furnace axis at about 20° to the horizontal and with a relatively high speed of rotation of about 30 revolutions per minute in order that the strong smoke formation at the oxidation of silicon phosphorus and manganese shall be counteracted. After said blowing period when the boiling sets in seriously and gives rise to a sufficient stirring, and the rotation is interrupted and the furnace is raised to a substantially vertical position. In connection therewith a slag is tapped, and a further quantity of 1000 kgms. of limestone and 1500 kgms. of ore is charged to the bath in the furnace. The blowing is then continued by blowing oxygen, through a vertical oxygen twyer, against the bath under conditions to displace slag and bring the oxygen stream into direct contact with the surface of

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the underlying metal. The furnace is not rotated during this phase which lasts about 10 minutes and brings the carbon percentage down below 0.3%. At the final phases of the process, which takes about 3 minutes, the blowing is again carried out with the furnace rotating in a substantially horizontal position in order that the speed of reaction between the slag and the steel bath shall be increased and thereby the iron losses in the slag be reduced. After this phase the steel is tapped in a ladle as in conventional practice.

If desired and for the purpose of cooling the bath during the process ore as well as scrap iron can be added continuously or at suitable intervals. If scrap iron of a coarse kind is to be added to the molten bath it should preferably be supplied immediately before raising the furnace into a vertical position. Finer scrap iron can be added without disadvantage also before or during the rotation.

Pig iron of other types may be refined by similar methods. As a rule, it is suitable to limit the time of blowing in the rotary furnace as far as possible without unfavourably influencing the progress of the process thereby, and to carry out the rest of the blowing, usually under an intermediate period when the carbon refining is vivid, with the furnace stationary or only slowly rotating in vertical position. In such manner the life time of the furnace lining can be considerably increased and the advantages of the rotation effect simultaneously be fully utilized.

During the boiling period the gas development always causes an increase of the volume of the charge which can be considerable, particularly if the slag simultaneously formed in the furnace gets into foaming, which is often the case. Owing to the fact that the permissible degree of filling of the furnace is greater in the vertical position than in the horizontal it is consequently possible to use a greater charge in the furnace if the blowing is carried out with the furnace in the more or less vertical position, at least during the most vivid boiling. An increase of the blowing speed or intensity is also obtainable with this mode of operation.

It is an advantage with the present method that it is particularly well suited for refining pig iron of high silicon percentages. If the percentages of silicon exceeds 1 to 1.5% it has appeared to be difficult to start the reaction at the beginning of the blowing if the process is carried out in a stationary furnace. By rotation of

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the furnace so that a vivid bath movement is produced the reaction starts immediately and when the percentages of silicon has been reduced the blowing may be continued with the furnace in vertical position when found suitable from other points of view.

What is claimed is:

1. In refining molten ferrous metal containing carbon in a tippable furnace rotatable about an axis of rotation by blowing the molten metal with a gas containing at least 40% free oxygen the improved method which comprises performing said blowing during a stage of the process during which the furnace rotates with its axis of rotation inclined not more than 45° from the horizontal the oxygen containing gas being introduced through a central opening in an end wall of the furnace and during another stage of the process during which the axis of rotation of the furnace is approximately vertical, the oxygen containing gas being supplied to the molten metal from above.

2. The method defined in claim 1 in which the first stage of the blowing takes place with the furnace rotating with the axis of rotation in an inclined position, and in which silicon and manganese present in the metal are oxidized while iron losses into the slag are reduced.

3. The method defined in claim 1, in which the last stage of the blowing is carried out with the furnace rotating with the axis of rotation in the inclined position for reducing the iron losses in the slag.

4. The method defined in claim 1, in which the blowing is carried out during at least a portion of the so called boiling period with the axis of rotation of the furnace in the substantially vertical position.

5. The method defined in claim 1, characterized in that the metal to be refined has a silicon content higher than 1%.

6. The method defined in claim 1 characterized in that the metal to be refined contains more than 0.5% P.

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