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DESULPHURIZATION OF CAST IRON

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1 Claim. (Cl. 75—12)

This invention relates to the desulphurization of cast or pig iron and has for its object to provide an improved process for this purpose, which shall be more economical and rapid than those previously employed thereby enabling low grade ore having a relatively high sulphur content to be utilised for smelting to produce an iron having the necessary degree of purity in this respect without unduly increasing the cost of manufacture.

Sulphur is well known to be a most detrimental impurity in iron and steel and it has previously been necessary to eliminate this impurity, which is derived either from the ore itself or from the fuel employed in smelting, to the necessary extent, either by selecting ore having an originally low sulphur content or by the employment of basic slag-forming substances capable of combining with, and thus fixing a portion of the sulphur.

In the manufacture of steel in a basic electric furnace the sulphur content can also be reduced by treating the melt in the furnace with a desulphurizing slag as a final purifying operation.

These processes and the products obtained are, however, subject to technical and economical limitations which during recent years have become more serious and important, partly due to the increased demand for pig iron having a low sulphur content and partly to the attempts at reducing the cost of the iron produced by utilising less expensive sulphur-containing fuels and ores. In order to render the final product independent of the original sulphur content of the pig iron produced in a blast furnace or remelted in a cupola furnace, it has therefore been proposed to treat the molten pig iron with soda ash which reacts with the sulphur and removes part of it from the iron. The desulphurizing power of soda ash has been known for a considerable time, but the methods of utilizing it have not been developed in commercial form until recently.

Amongst other processes proposed and utilised on a commercial scale the soda ash, with or without lime and other substances such as fluorspar, has been added to the molten iron in a ladle, in the runner of a blast furnace or in the forehearth of a cupola furnace. In order to cause a stirring effect so as to ensure intimate mixture of the soda ash with the pig iron and thereby improve the result, a process has been tried in which the pulverized or previously molten soda ash is at first introduced into the ladle, and the molten iron is then poured into the soda ash in the ladle from a relatively considerable height. The mixture of the soda ash with the iron has also been effected by utilising a moving fore-hearth furnace.

The desulphurization obtained by treatment with soda ash according to the processes above described amounts on an average to about 60% of the initial sulphur content. Depending on this original sulphur content of the pig iron the consumption of soda ash amounts to approximately 7 to 20 kg. per metric ton of pig iron and the permissible original sulphur content is increased to approximately twice the quantity previously allowable in the pig iron as tapped from a blast furnace. By using these processes, however, it is impossible to produce economically a practically sulphur-free pig iron having less than 0.010% of sulphur, unless the raw material initially contained a very low percentage of sulphur. Otherwise the quantities of soda ash required to be added are such as to prevent economical production.

Although these desulphurization processes hitherto employed have thus effected a considerable improvement, they have not been successful in providing a solution of the technically and economically very important problem, namely, the required desulphurization on a mass production scale so that high grade as well as ordinary ferrous metals could be manufactured independently of the initial sulphur content of the raw material.

It has now been found, however, that by utilising low frequency alternating electric currents in the manner more particularly hereinafter described, a very considerable and, if desired, complete desiphurization can be obtained so rapidly and by using such small amounts of added materials that a practical solution of the problem above referred to has been found.

According to the principal feature of the invention the molten metal obtained from a blast or cupola furnace is introduced into one or more reaction containers in the form of furnaces, ladles or the like, in which, either in a single charge or in a number of separate portions it is emulsified or intermixed with a slag containing lime or other calcium compounds, such as calcium carbide, and/or one or more alkaline compounds such as soda ash, potash or the like, the emulsifying or intermixing action being produced by means of induced low frequency alternating electric currents. Frequencies suitable for this purpose are the usual power supply circuit frequencies of from approximately 16 to 50 cycles per second, but higher or lower frequencies may also

be employed and the term low frequency as used in this connection is only intended to distinguish the frequencies contemplated according to the invention from the so-called high frequencies of about 500 to 2000 cycles per second commonly utilised in metallurgical melting furnaces.

When using two or more reaction containers it is desirable in order to reduce capital and operating costs, to employ the containers alternately in such a manner that one container is filled or tapped while the melt in another container is being intermixed with slag, or, in other words, that the one container is not being supplied with current while the other is being thus supplied.

In this manner of carrying the invention into practice it is unnecessary for the capacity of the electric equipment to correspond to the total current consumption of all the containers as this capacity need be sufficient for the container or containers operative at a time so that the electric equipment may be smaller and more evenly loaded. By employing a greater number of containers it is possible, on the same principle, successively to connect the containers singly or in groups to the source of current.

In order to enable the same reaction containers to be employed for a number of blast furnaces or the like, these containers according to the invention, may be mounted separately or in groups on a movable support.

The electric equipment may comprise alternating current inductor windings or coils of any suitable character adapted for operation at the frequency utilised. For example, induction furnaces having annular or crucible-shaped melting spaces may be employed for this purpose. It is, however, unnecessary to incorporate the windings etc. permanently with the furnace as a unit as has previously been customary, as the windings etc. may be constructionally separate from the furnace, container or the like and if desired, may be constructed in the form of a cylinder, ring or block arranged to be placed around or immediately above the molten metal in the container or the like. The electrical portion of the equipment or the container or both may thus be rendered movable and in this manner it is possible to use the same equipment for a number of furnaces, containers or the windings etc. as an element adapted to be placed in position above and at a suitable distance from the surface of the molten metal has the advantage that the stirring effect is concentrated at the place where it is most useful, i. e. at the boundary layer between the molten metal and the slag.

The inductor windings may be arranged for operation by single or polyphase current and if for example, three-phase current is employed, a moving magnetic field may be generated similar to the rotating field of a three-phase induction motor. The molten metal being thus caused to flow in the direction of movement of the magnetic field. It is, for instance, possible to cause the metal to flow radially outwards so that it rises in the centre and sinks at the walls of the melting chamber. By suitably constructing the windings and cores, so as to take advantage of the mechanical forces exerted between the primary and secondary current circuits, it is possible to influence the shape of the metal surface so that, for example, this surface becomes concave during operation thereby reducing destructive action of the slag on the lining of the melting chamber.

The inductor windings should be suitably watercooled and may, if desired, be protected by a suitable fire-proof material which if electrically conducting should be laminated or suitably subdivided for the purpose of reducing losses due to eddy currents.

The inductive stirring devices may be employed in furnaces having electric or other heating as well as in ladles or the like not provided with heating devices and by suitably designing the equipment and using an alternating current of suitable frequency, the induction currents may be caused also to generate sufficient heat for the maintenance of a suitable reaction temperature.

If basic slags are used in reaction containers having linings containing silica, the basic ingredients of the slag will react with the silica and, consequently, the desulphurising power of the slag will be reduced, which can only be counteracted by the addition of larger quantities of desulphurizing slag. The process according to the present invention, in such cases, may be further improved by using a basic lining or a lining which is neutral to the slag, i. e. a lining which contains no silica or only a small percentage thereof. Such lining materials are, for instance, dolomite, magnesite or these substances mixed with tar. Alumina, zirconium oxide, graphite etc. may be employed for this purpose but owing to their low cost and good satisfactory result rammed linings composed of a mixture of tar and dolomite are particularly suitable. Linings composed of a mixture of tar and magnesite may also be employed in the same manner.

A suitable basic reaction slag containing one or more of the substances soda ash, potash, lime and calcium carbide together with fluorspar or other fluxing agents may be introduced into the furnace, ladle or the like before, at the same time as, or after the molten pig iron, the latter being tapped directly from the melting furnace (blast furnace, cupola furnace or the like) or from a ladle.

In order to illustrate the remarkably good results obtained by the invention the following examples of actual experiments are given:

Example 1.—1500 kg. of pig iron containing 0.138% sulphur were treated with inductive stirring at a temperature of approximately 1350° C. for a period of 5 minutes with a slag consisting of 16 kg. lime and 11 kg. fluorspar, this slag thus amounting to 1.8% of the weight of the pig iron, the sulphur content being thereby reduced to 0.046%. Then 3 kg. of soda ash was added (i. e. 0.2% of the weight of the pig iron) and the stirring action was continued for another 3 minutes. The sulphur content was thereby reduced to 0.011%. This experiment was carried out in an induction furnace lined with magnesite and supplied with alternating current at a frequency of 33 cycles per second, the consumption of energy being only 9 kw.-hr. per metric ton of pig iron.

Example 2.—1200 kg. of pig iron having a sulphur content of 0.010% was treated with inductive stirring for a period of 5 minutes in the same furnace as in Example 1 and at the same temperature with a slag consisting of 3 parts of lime and 4 parts of fluorspar the amount of slag employed being 1.7% of the weight of the pig iron, the sulphur content being thereby reduced to 0.005%. Soda ash to the amount 0.7% of the weight of the pig iron was then added and the stirring action continued for another 2 minutes. In the subsequent analysis even traces of sulphur could not be found in the pig iron.

Example 3.—1200 kg. of pig iron having a sulphur content of 0.067% was treated with inductive stirring for a total period of 9 minutes under the conditions described but at a temperature which was 100° C. higher with 2.4% of slag consisting of 3 parts of soda ash, 4 parts of lime and 3 parts of fluorspar. By this treatment the sulphur content was reduced to 0.002%.

The reaction times given in the above examples should by no means be regarded as the possible minimum, the reaction between the sulphur and the slag emulsified with the molten metal being almost instantaneous.

From the above examples it is obvious that the invention renders it possible to obtain a sufficient desulphurization for practical purposes with a slag consisting only of lime and fluorspar, while an even higher degree of purification may be attained by the addition for instance of soda ash.

A practically complete desulphurization is thus attainable in only a fraction of the time hitherto necessary for such processes, as is obvious from the above examples, and the invention thus enables the complete desulphurization of pig iron to be economically effected on a large scale independently of the original sulphur content of the raw material.

The importance of the invention for blast furnace operation will be immediately obvious since the utilisation of cheaper sulphur-containing ores and fuels is rendered possible and above all the invention enables acid slags to be employed in the blast furnace, thereby considerably reducing the comsumption of coke and lime, and consequently the cost, while at the same time increasing the output.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

Process for removing sulphur from a pig iron containing the same, which comprises producing a fluid melt of sulphur-containing pig iron in a furnace, tapping said melt into a container provided with a refractory lining which is substantially free from silica and is neutral to basic, introducing into the iron melt a small but effective amount of a basic slag comprising lime and fluorspar as flux, and inductively producing turbulent motion in the resulting mixture by the action of low frequency alternating electric current for a period of a few minutes, whereby the iron is rapidly and thoroughly contacted with the slag, thereupon adding a small but effective amount of soda ash to the mixture while continuing the turbulent motion of the latter as before for a period of a few minutes, and thereafter separating the resulting sulphur-containing molten slag from the desulphurized iron.

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