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Carlsson et al.

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[54] **STEEL MANUFACTURE**

[75] Inventors: **Lars Erik Carlsson,** Borlange; **Nils Fredrik Grevillius; Lars Ivar Hellner,** both of Karlskoga, all of Sweden

[73] Assignee: **Allmanna Svenska Elektriska Aktiebolaget,** Vasteras, Sweden

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 305,681, Nov. 13, 1972, abandoned, which is a continuation of Ser. No. 54,480, July 13, 1970, abandoned.

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[2] **C21C 7/02;** C21C 7/06; C21C 7/10

[58] **Field of Search** 75/49, 54, 55, 57, 58, 75/95

[56] **References Cited**

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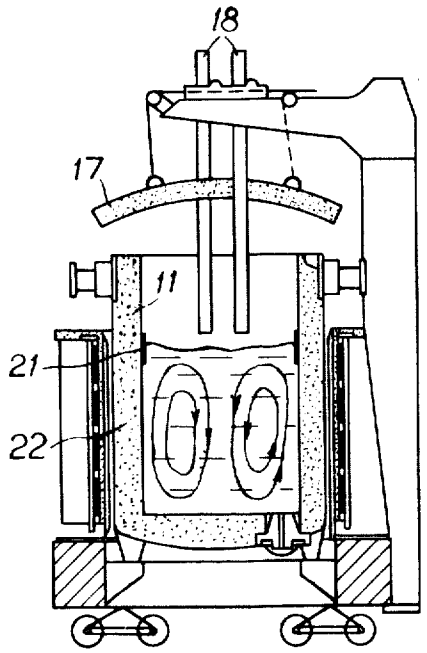
Primary Examiner—Winston A. Douglas
Assistant Examiner—Mark Bell

[57] **ABSTRACT**

A method for desulphurizing steel in heats over 1 metric ton in a container, such as a ladle furnace. The container is provided with a basic slag line and additionally with a lining which substantially prevents oxygen from leaking in through or from the lining. Basic slag-formers such as lime are added to the steel melt in the container in order to obtain highly basic slag and other desulphurizing agents such as misch metal may be added. The melt is well deoxidized by means of vacuum degassing or precipitation deoxidation, and subjected to vigorous stirring and heating during the process.

3 Claims, 1 Drawing Figure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STEEL MANUFACTURE

RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 305,681 filed Nov. 13, 1972 which is in turn a streamlined continuation of application Ser. No. 54,480, filed July 13, 1970, both now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing high-class steel in heats over 1 ton in a container, for example a ladle furnace.

2. The Prior Art

High-grade steel must fulfil high standards of freedom from non-metallic inclusions and other impurities. This means, for instance, that the phosphorus, oxygen and sulphur contents of the steel must be low and the tapping and casting carried out correctly. The most usual method hitherto used of manufacturing high-grade steel is melting in electric arc furnaces by two slag methods. The tap to tap time is thus divided into two main periods: the first covering deoxidation and desulphurizing. The latter period, called the reducing period, might comprise 30% of the total tap to tap time. By virtue of modern degassing methods, principally the ASEA-SKF process developed in Sweden, a steel having very slight content of oxide inclusions can be manufactured without a reducing period in the melting furnace (ASEA Journal 39(1966):6–7, pages 87–95). In previously known degassing processes, however, the desulphurizing is negligible. With the method developed according to which desulphurization is effected simultaneously with the deoxidation, a considerable increase in production can be achieved and at the same time the steel manufactured in this way is of extremely high quality.

Desulphurizing according to the two-slag process in an electric arc furnace is a time-consuming and laborious method and it is therefore expensive. Neither is sufficiently low oxygen potential achieved with this method. The yield from the additives for desulphurizing is therefore unsatisfactory. Considerable efforts have been made to obtain a high-quality desulphurized steel on an industrial scale in containers outside the electric arc furnace. However, so far this has not been achieved, which is probably due principally to too short treating times without the possibility of heating, and to insufficient stirring. Desulphurizing on an experimental scale has been reported to produce very low contents using desulphurizing agents such as SiCa, AlCa and CaC_2, for example.

SUMMARY OF THE INVENTION

The invention aims at carrying out desulphurization in a container outside the arc furnace on an industrial scale. The advantages of the invention are that desulphurization can be carried out very cheaply and to extremely low percentages of sulphur and the capacity of the furnace is increased.

The method demands that certain practical problems, for instance concerning oxygen content, durability of the lining, oxygen leakage from the lining and bath surface and the contact between steel and desulphurizing agent must be solved. The invention is characterised in that lime and/or some other basic slag-former is added to a steel melt in the container to obtain highly basic slag; and other desulphurizing additives may be used, especially misch metal, the melt being well deoxidized and being subjected to vigorous stirring and heating during the process.

For practical reasons the desulphurizing process should be carried out in the same ladle furnace as is used for degassing the steel, but it may also be carried out in another container. The desulphurizing process is based on reaction with a molten slag phase, which must be highly basic, and additions of solid reaction agent, principally misch metal. Steel furnaces intended for operation under vacuum are usually lined with neutral brick which is, however, attacked by basic slags. Furnaces in which desulphurization is carried out according to conventional methods are usually lined basically. Such linings are sensitive to temperature fluctuations, which makes them unsuitable for use in containers and furnaces of the type intended.

The invention is particularly characterised by the fact that aluminum is added to keep the oxygen activity low; that the furnace wall, at least at the slag line, is formed of basic brick; and that the misch metal is introduced without contact with the molten slag at a point where the melt is on a downward part of the stirring path, so as to prevent to a great extent contact between the misch metal and the molten slag.

A steel manufactured in this manner is of extremely high quality and its manufacture may be carried out on a large scale at low costs. The steel obtained can be cast continuously or in batches.

BRIEF DESCRIPTION OF THE DRAWING

The drawing shows in cross-section a furnace of the type which may be used in carrying out the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The method according to the above may be used for example in a furnace of the type used for the ASEA-SKF process and which is shown in the drawing (see also application of Karlsson et al. Ser. No. 538,633, filed Mar. 30, 1966, now abandoned). This is a ladle furnace with the ladle **11** and its lining **22.** The basic slag line is shown at **21.** The basic slag line is always manufactured from basic brick. The lining may otherwise be made in a high-value neutral brick containing Al_2O_3 or in basic brick. In either event, the lining is such as or at least substantially to prevent leakage of oxygen from the lining into the melt.

A typical basic slag line may have the following composition:

96 – 97%	MgO
0.7%	SiO_2
0.3%	Al_2O_3
0.2%	Fe_2O_3
0.3%	Cr_2O_3
1.4%	CaO

(Steetly M5B)

In the rest of the lining, the composition may be:

21%	SiO_2
2.6%	TiO_2
73%	Al_2O_3
1.2%	Fe_2O_3
0.2%	CaO
0.2%	MgO
0.3%	alkali metal compositions.

Type Hoganas H W M (Harbison Walker)

A steel melt may be tapped into such container or ladle which is provided with a lid having through electrodes, and the melt is thus heated to a certain temperature by means of electric arcs under the lid. In the meanwhile lime is added which melts and a basic and well reduced slag is formed. Stirring is carried out the whole time by electro-magnetic multiphase stirrers. As shown in the drawing, this stirring has a vertical nature, that is, the melt moves in a pattern having upward and downward components. The container is then provided with a vacuum lid with evacuating means and degassing is carried out to reduce the percentage of oxygen and other noxious gases. When the desired degree of degassing has been achieved, the vacuum is removed and aluminum and then misch metal are added (for example, half the total amount of misch metal), the melt still being stirred and heated, for example for about 15 minutes after which aluminium, if it is to be added, and part of the remaining quantity of misch metal are added while the melt is stirred and heated for another 15 minutes. Aluminum and the remainder of the misch metal are then added and the melt stirred for approximately the same length of time. The misch metal may be added in one step or in several, as in the example. If the process is used in a container without vacuum treatment, this is replaced by precipitation deoxidization with a strong deoxidant, for example aluminum. The melt obtained in this way is of high quality with low sulphur and oxygen contents.

If the melt has a sufficiently high temperature when it is tapped into the container, the vacuum may be applied directly, after which the highly basic slag is produced and aluminum and misch metal are added during heating and stirring. The vacuum treatment is carried out until the desired low gas content is achieved.

The electro-magnetic stirring may be replaced by stirring by means of blowing in gas or mechanical stirring (mechanical stirrer or vibratory ladle) and the heating may also be carried out by some other means than with electric arcs.

The purpose of the stirring is to ensure that all parts of the melt will be reached by the degassing effect and to effect satisfactory contact between the desulphurizing slag and any added desulphurizer and the steel melt.

Leakage of oxygen from the lining to the melt is prevented by using a basic lining or high-value lining of neutral brick containing Al_2O_3. At the slag line the lining should be basic to prevent it from being strongly attacked by the highly basic slag.

The desulphurizing process requires a well deoxidized steel. This is obtained in the ladle by means of vacuum treatment with a vacuum lid applied on the container or a vacuum tank surrounding the container and/or by the addition of a powerful deoxidant to the slag, for example aluminum, and stirring the melt by means of electro-magnetic low-frequency stirrers or by blowing in gas or by mechanical means.

During desulphurizing the melt should be covered by molten highly basic slag preferably prepared from lime, reduced with aluminum and possibly with the addition of fluxing agent. Fluospar may be added at the time of casting in order to prevent the slag from freezing. The lime should be well dried to prevent increased hydrogen content in the melt. The highly basic slag prevents disturbing leakage of oxygen from the bath surface and also has a partial desulphurizing effect. In many cases the desulphurizing obtained in this way is quite sufficient.

The lime should be added in quantities of 0.2 – 2.0, suitably 0.3 – 1.5 per cent by weight, preferably 0.5 – 1.0 per cent by weight of the total charge weight. Misch metal is added for the desulphurizing process in quantities of up to 1% of the charge weight, suitably up to 0.3%, preferably 0.1 – 0.2 %.

Calcium may also be added for the desulphurizing process, preferably in the form of calcium alloys corresponding to up to about 0.5 per cent by weight calcium of the charge weight, preferably 0.2 – 0.3%, or magnesium may be added for the same purpose, preferably in the form of magnesium alloys, added in the same quantities. Combinations of these (Ca, Mg) may also occur.

In experiments using a 50 ton charge weight for desulphurizing in a vacuum ladle, the ladle was provided with a basic slag line and the conventional neutral lining otherwise. In all the experiments lime was added in quantities which are set out in the following.

After normal degassing under a vacuum lid (see ASEA Journal mentioned above), 100 g Al/ton was added. In one charge (1) no other desulphurizing agent than lime was added to the melt, whereas in the other experiments (2–5) misch metal was also added in different quantities. The misch metal was added by immersing tins in the bath in three batches (see above), at intervals of about 15 minutes between the batches. The misch metal is thus introduced through the slag without contact therewith, in a portion of the stirring pattern where the melt is moving downwardly. Al is always added before the misch metal in order to keep the oxygen activity low. As mentioned, the quantity of aluminum added first was 100 g/ton and after that 50 g/ton on each occasion.

The following results were obtained for the five charges:

Heat no.	Steel Quality	Additives Lime %	Additives Misch metal %	Sulphur Content Before Tapping	Sulphur Content Casting
1	SIS 1650	0.5	—	0.037	0.016
2	SIS 1650	0.8	0.2	0.034	0.001
3	SIS 1650	0.8	0.05	0.038	0.016
4	SIS 2225	0.8	0.1	0.025	0.005
5	SIS 2511	0.8	0.2	0.032	0.002

As can be seen, the degree of desulphurizing was greatest when misch metal was added also (charges 2–5), but even with only the addition of lime (basic slag) satisfactory desulphurizing was obtained (1).

The following table shows the result of two heats manufactured without vacuum-degassing.

Heat No.	Steel Quality	Lime %	Misch metal %	Before Tapping	In mould
6	SIS 1650	0.8	0.2	0.024	0.001
7	AISI H 11	0.8	0.25	0.015	0.002

In experiments using about 1 ton charge weight without vacuum treatment, the following results were obtained. During the experiments the lower part of the container was neutrally lined and its upper part basically lined. During the experiments additions were made as shown below:

Heat No.	Steel Quality	Desulphurizing Agent	Quantity %	Sulphur Content % Before Treatment	Sulphur Content % After Treatment
8	SIS 1572	misch metal	0.2	.050	.004
9	SIS 1572	misch metal	0.3	.039	.005
10	SIS 2225	misch metal	0.3	.028	.007

A highly basic slag is at the surface of the bath, in experiments 8 – 10 up to 1.0% of the charge weight.

The invention can be varied in many ways within the scope of the following claims.

We claim:

1. Method of desulphurizing deoxidized melts of steel in charges over 1 ton in a container, which container is provided with a lining which substantially prevents oxygen from leaking in from the lining, and which includes a basic slag line liner at the slag line which comprises adding to the molten steel at least one basic slag-former in the container in order to obtain a high basic molten slag, adding aluminum to the melt and adding misch metal directly into the melt as a desulphurizing agent without substantial contact with the slag and principally at a point of downward movement in the stirring pattern.

2. Method according to claim **1,** in which said misch metal is added in a quantity of up to one per cent of the charge weight.

3. Method as claimed in claim **1,** in which a vacuum is maintained above the melt during the desulphurizing.

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