METHOD FOR PRODUCING FOAMED SLAG ON HIGH-CHROMIUM MELTS IN AN ELECTRIC FURNACE

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Abstract

The invention relates to a method for producing foamed slag on high-chromium steel melts in an electric furnace, whereby a mixture consisting of a metal oxide and carbon is introduced into the furnace, the metal oxide in the slag is reduced by the carbon, and the gases created in the slag form bubbles which thus foam up the slag. In order to be able to control the gas formation and thus the foaming process, the mixture consisting of a metal oxide and carbon and optionally an iron carrier is introduced as preforms, such as pellets, which are compressed and/or provided with a binding agent. The gas formation can be controlled in terms of location, type and time, by adjusting the characteristics of the pellets, especially the density and/or compression characteristics thereof.
METHOD FOR PRODUCING FOAMED SLAG ON HIGH-CHROMIUM MELTS IN AN ELECTRIC FURNACE

BACKGROUND OF THE INVENTION

The invention concerns a method for producing foamed slag on high-chromium steel melts in an electric arc furnace, wherein a mixture of a metal oxide and carbon is introduced into the furnace. The metal oxide is reduced by the carbon in the slag, and the resulting gases bring about the foaming of the slag by bubble formation.

In the operation of electric arc furnaces, the charge, i.e., mainly scrap, and alloys are melted by the electric arcs of the electrodes, which extend downward into the furnace shell. The slag fulfills not only its primary function, i.e., the removal of undesirable components from the melt, but also a protective function in the foamed state. In this state, the slag envelopes the space between the ends of the electrodes and the surface of the metal and protects the refractory lining of the furnace from radiant energy of the electric arc. Due to the low thermal conductivity of the foamed slag, the radiation of the electric arc towards the wall of the arc furnace is greatly reduced, and thus the energy input into the melt is improved.

In the case of nonstainless steels or steels with a low chromium content, the foamed slag is produced by simultaneous injection of carbon and oxygen onto the slag and into the steel bath, respectively. The gas that evolves during the reactions that occur causes foaming of the slag. In addition, the carbon reduces the ferrous oxide to iron and carbon monoxide according to the equation:

\[ \text{FeO} + \text{C} \rightarrow \text{Fe} + \text{CO} \]

The foamed slag encases the electrodes and is present as a protective layer between the electric arcs and the furnace wall.

In the case of high-chromium melts, the injected carbon reacts basically as a reducing element of the chromium oxide. The reactions specified above have little importance in the metal bath. Besides, the content of iron in the slag is too low to guarantee satisfactory foaming of the slag. All together, in the case of high-chromium melts, it is difficult, due to the differences that have been mentioned, to produce a foaming slag in the superheating phase.

For this purpose, EP 0 829 545 B1, which concerns a method for producing a foamed slag on molten stainless steel in an electric arc furnace, proposes that a powder, which consists of a metal oxide, either zinc oxide or lead oxide, and carbon, be introduced into the slag. The oxide contained in the powder is reduced by reaction with the carbon. Bubbles consisting mainly of carbon monoxide are formed in the slag and cause the slag to foam. The powder is introduced into the slag with the aid of an injection medium, for example, nitrogen.

Thus, in accordance with the prior art, the reactive mixture is introduced into the slag or melt as a powder. Due to the relatively large surface area associated with the powdered form, brief, violent reactions occur. Moreover, the reaction is locally limited in the vicinity of the injection device and here especially at the tip of the injection lance in the molten bath.

SUMMARY OF THE INVENTION

Proceeding from this type of prior art, the objective of the invention is to develop a method for producing foamed slag on molten high-chromium steels in an electric arc furnace, in which the processes that initiate the foaming reaction occur in a controlled way.

In accordance with the invention, the furnace is charged with a mixture of a metal oxide and carbon, not as a powder but rather as compressed preforms and/or preforms provided with a binder. In addition to the preferred pelletized form, it is possible to use other forms, for example, the briquet form. The systematic adjustment of the properties of the preforms, hereinafter referred to in terms of their embodiment as pellets, makes it possible, in contrast to use in powdered form, to control the evolution of gas with respect to location, type, and time—especially the starting point with respect to time, the rate, the intensity of the reaction, and/or the duration of the reaction.

In particular, the density properties of the pellets are adjusted by the compression pressure and/or the type and amount of an admixed iron carrier, for example, ferromnical, and a binder. In this regard, in accordance with a preferred variant, the density of the compressed preforms is adjusted in such a way that the pellets float in the slag near or directly on the metal-slag phase boundary itself. The addition of the iron carrier ensures that the pellets are heavier than the slag but lighter than the metal melt. The evolution of gas thus occurs in a locally well-defined way, namely, in the slag at the boundary between the metal and slag. In this way, there is no contact between pellets and metal bath, so that carburization of the melt is prevented. It is also possible to adjust the pellet properties in such a way that the pellets can occupy different positions between the molten bath and the slag. This guarantees that the processes that initiate the foaming occur only in the slag, so that the effectiveness is increased.

Furthermore, the pellets should have a density or a degree of compaction that causes them to disintegrate uniformly and slowly, so that the foaming reaction occurs uniformly and over a relatively long period of time. In addition, it is possible to cause the reactions to occur with a time delay by using even higher pressure compaction. This prevents the reaction from occurring too soon and guarantees that the reaction will not start until the pellets are distributed in the slag.

In addition, the evolution of gas can be systematically adjusted by the size of the pellets. As a result of the fact that the pellets have a relatively large diameter and thus a smaller specific surface than powders, the foaming reaction can be maintained for relatively long periods of time with uniform gas evolution.

The basic components metal (Me) oxide and carbon are involved in the following reactions:

\[ \text{Me}_x\text{O}_y + \text{C} \rightarrow \text{Me}_x + \text{CO} \]

\[ \text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2 \]

Waste products of steel production can be used for the mixture for producing the pellets, such as carbon from
consumed electrodes or pieces of waste scale. The use of binders is advisable especially with mixtures of this type.

Aside from the basic components metal oxide and carbon, a flux, especially limestone, is additionally pressed into the proposed pelletized form. The desired CO/CO₂ formation is additionally intensified by the limestone. Furthermore, a slag thinner, preferably CaF₂, can be additionally pressed into or bound with the mixture. This counteracts the tendency of chromium-containing slags to become increasingly viscous with increasing chromium oxide content.

It is also advisable to press a reducing agent, such as silicon and/or aluminum, into some of the pellets, especially together with limestone, to control the chromium oxide content of the slag. These reducing agents reduce the chromium oxide contained in the slag and thus lower the chromium content of the slag. In addition, the foaming of the slag is improved.

In contrast to powder, which must be locally injected, the pellets are added in various parts of the furnace through the furnace roof and/or the sidewalks of the furnace. This is not possible with powder, because large fractions of the powder would be sucked out by the dust removal system of the furnace. It is also advisable to introduce the pellets into the slag in a directed way in the vicinity of and directly at the hot spots of the electrodes to allow the foaming process to occur especially at the electrodes.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of the disclosure. For a better understanding of the invention, its operating advantages, specific objects attained by its use, reference should be had to the drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

**BRIEF DESCRIPTION OF THE DRAWING**

In the drawing:

- FIG. 1 shows a schematic representation of the cross section of an electric arc furnace with charging devices for the slag-foaming pellets.
- FIG. 2 shows the furnace in FIG. 1 from above.

**DETAILED DESCRIPTION OF THE INVENTION**

The electric arc furnace shown in FIG. 1 comprises a furnace shell 2 with a refractory wall 3 and a furnace roof 4. After the furnace has been charged with scrap and alloying components, three electrodes (in the present case) 5a-c are lowered into the interior of the furnace. The solid material is melted down by the electric arcs that are produced. A slag layer 7 is formed and floats on the melt. To initiate a foaming reaction of the slag 7 between the electrodes 5a-c and the refractory furnace wall 3, slag-foaming material is introduced into the interior of the furnace as preforms 8, namely, in the form of pellets. The pellets are preferably charged through the furnace roof 4, specifically, through the fifth roof hole 9, and/or the sidewalks 10. Injection systems with injection lines or gravity feed systems 11 that extend through the sidewalks 10 of the furnace are provided for this purpose. Instead of injection lines, it is also possible to use injection lances.

Alternatively or additionally, a pneumatic conveyance system 12 consisting of closed circular pipelines is also suitable for charging the pellets. This system has a closed circular pipeline 13 that runs along the roof 4, as shown in FIG. 2, which at the same time also has closed circular pipelines 14 that run radially to the roof. Three charging holes 15a-c (in the illustrated example) are provided in the closed circular pipelines 13, 14 and the corresponding roof wall. The pellets are introduced into the furnace slag 7 uniformly over the cross section of the furnace by this system 12. In this regard, the charging holes 15a-c are arranged in such a way that the pellets react with the slag 7 in the vicinity of the hot spots.

The pellets float in the slag 7, where they react to produce the desired gas evolution and thus foaming reaction in a way that is controlled with respect to location, time, and type. In particular, the adjustment of the density and size of the pellets makes it possible to ensure that the gas evolution process proceeds as uniformly as possible, for a relatively long time and not too violently. A controlled reaction at the surface of the pellets results in uniform foaming of the slag.

While specific embodiments of the invention have been shown and described in detail to illustrate the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles. We claim:

1. Method for producing foamed slag (7) on high-chromium steel melts (6) in an electric arc furnace (1), wherein a mixture of a metal oxide and carbon is introduced into the furnace (1), the metal oxide is reduced by the carbon in the slag (7), and the resulting gases form bubbles in the slag, which thus cause the slag to foam, wherein the mixture of metal oxide and carbon is introduced into the furnace as compressed preforms (8) and/or preforms (8) provided with a binder.

2. Method in accordance with claim 1, wherein the density of the preforms (8) is adjusted in such a way that they float in the slag (7).

3. Method in accordance with claim 1, wherein the density of the preforms (8) is adjusted in such a way that they float in the slag near the phase boundary between the melt (6) and the slag (7).

4. Method in accordance with claim 2, wherein the density of the preforms (8) is adjusted by the addition of an iron carrier.

5. Method in accordance with claim 1, wherein the density of the preforms (8) is adjusted in such a way that they disintegrate in the slag (7) uniformly and slowly, and the evolution of gas occurs uniformly and over a relatively long period of time.

6. Method in accordance with claim 1, wherein the density of the preforms (8) is adjusted in such a way that they disintegrate with a time delay.

7. Method in accordance with claim 1, wherein a flux, preferably limestone, is additionally added to the mixture.

8. Method in accordance with claim 1, wherein a slag thinner, preferably CaF₂, is additionally added to the mixture.

9. Method in accordance with claim 1, wherein a reducing agent, preferably silicon and/or aluminum, is additionally added to the mixture.

10. Method in accordance with claim 1, wherein the preforms (8) are introduced through the sidewalks (10) and/or the furnace roof (4) of the electric arc furnace (1).

11. Method in accordance with claim 1, wherein the preforms (8) are introduced into the slag (7) in a directed way in the vicinity of or directly at the hot spots of the electrodes (5a-c).

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