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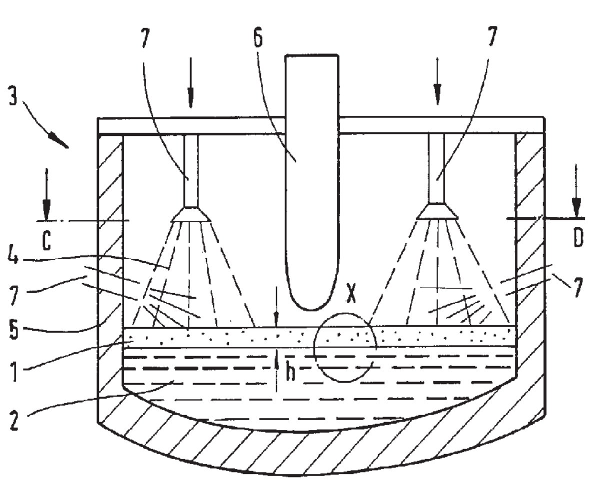
(54) **Title:** METHOD FOR THE PRODUCTION OF A FOAMED SLAG IN A METAL BATH

(54) **Bezeichnung:** VERFAHREN ZUR ERZEUGUNG EINER SCHAUMSCHLACKE IN EINER METALLISCHEN SCHMELZE



(57) **Abstract:** The invention relates to a method for producing a foamed slag (1) on a metal bath (2) in a metallurgical furnace (3). According to said method, a mixture (4) containing at least one metal oxide and carbon is introduced into the furnace (3), the metal oxide is reduced by means of the carbon below the slag (1) that is located there, and the gases produced during the reduction process form bubbles such that the slag is foamed. In order to optimize the formation of foamed slag, the mixture (4) is delivered into the furnace (3) in such a way that a desired height (h) or a desired section of the height (h) of the layer of foamed slag (1) is generated or maintained.

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WO 2007/087979 A1

GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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— *vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eintreffen*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(57) Zusammenfassung: Die Erfindung betrifft ein Verfahren zur Erzeugung einer Schaumschlacke (1) auf einer metallischen Schmelze (2) in einem metallurgischen Ofen (3), bei dem ein zumindest ein Metalloxid und Kohlenstoff enthaltendes Gemisch (4) in den Ofen (3) eingegeben wird, wobei unterhalb der dort befindlichen Schlacke (1) das Metalloxid durch den Kohlenstoff reduziert wird und wobei die bei der Reduktion entstehenden Gase in der Schlacke Blasen bilden, wodurch die Schlacke aufgeschäumt wird. Um die Bildung von Schaumschlacke optimal zu gestalten, ist erfindungsgemäß vorgesehen, dass die Zugabe des Gemisches (4) in den Ofen (3) so erfolgt, dass eine gewünschte Höhe (h) bzw. ein gewünschter Bereich der Höhe (h) der Schicht der Schaumschlacke (1) entsteht bzw. erhalten bleibt.

2007211649 19 May 2011

METHOD FOR THE PRODUCTION OF A FOAMED SLAG IN A METAL BATH

The invention concerns a method for producing a foamed slag in a metal bath in a metallurgical furnace, in which a mixture that contains at least a metal oxide and carbon is introduced into the furnace, and the metal oxide is reduced by the carbon and where the gases formed during the reduction form bubbles in the slag, thereby foaming the slag.

A method of this general type is disclosed by WO 2004/104232 A1. This previously known method can be used to produce a foamed slag on a metal bath, for example, on a bath composed of stainless metal. During the melting of the solid metal in an electric arc furnace, a slag forms that can contain a large fraction of Cr oxide. The concentration of this fraction often reaches values of greater than 30%. Due to their composition, slags of this type cannot be liquefied and foamed to the desired extent with the prior-art method.

The cited document describes the addition of a mixture that contains at least a metal oxide and carbon to the metal bath. In addition, the mixture can contain an iron carrier material and a binder. The mixture can be added to the bath compressed and in the form of pellets or briquettes. If the mixture is introduced into the region between the metal bath and the slag layer, it can chemically react there, and a metal oxide reduction process starts to occur. This process of reduction of the metal oxide with the carbon leads to the formation of gaseous carbon monoxide (CO), which results in bubble formation, which produces foaming of the slag.

2669315_1 (GHMatters) P78603 AU 12/05/11

The advantage of producing a foamed slag consists in the following: During the operation of an arc furnace, the charge, e.g., the scrap to be melted down, is melted in the furnace by means of the arc of the electrodes. In this connection, the slag fulfills not only its primary function of removing undesired constituents from the metal bath but also a protective function due to its foamed state. Specifically, the foamed slag at least partially fills the space between the ends of the electrodes and the surface of the molten metal and thus 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 metal bath is improved.

Another advantage of the foamed slag is its noise muffling effect. The covered or enveloped electric arc thus emits less noise into the surroundings, which improves the environmental conditions in the vicinity of the furnace.

The present invention relates to a method for producing a foamed slag in a metal bath of a metallurgical furnace, in which a mixture that contains at least a metal oxide and carbon is introduced into the furnace, where the metal oxide is reduced by the carbon and where the gases formed during the reduction form bubbles in the slag, thereby foaming the slag, wherein the mixture is introduced into the furnace in such a way that a desired height (h) or a desired range of heights (h) of the layer of foamed slag develops and is maintained, and wherein the mixture is added in an amount of 3-20 kg per minute per metric ton of molten metal in the metal bath.

The addition of the mixture may be at a rate of 5-15 kg per minute per metric ton of molten metal.

It was found that the area of specific delivery of mixture may also be a parameter. In an embodiment, the mixture may be added in such a way that an amount of mixture of 15-35 kg/m^2 can be maintained on the surface of the metal bath. Ideally an amount of 20-30 kg/m^2 may be maintained on the metal bath.

It can be relevant that the mixture be delivered and act in the correct place. For example, it may be advantageous to introduce the mixture between the metal bath and the slag. This may be achieved by the mixture being compressed to a density such that the mixtures passes through the slag layer and float on the molten bath.

An electric arc furnace or melting unit with electrodes is usually used as the metallurgical furnace. In this regard, it can be especially advantageous if, with a furnace wall with an essentially circular design as viewed from above and with an essentially central arrangement of at least one electrode of the furnace, the mixture is added to an annular area between the electrodes and the wall. It has been found to be advantageous if the mixture is added in the vicinity of the radial center of this annular area.

The mixture may contain not only the metal oxide and carbon but also a carrier material composed of iron and chromium. In addition, it may contain a binder. The handling of the mixture is facilitated if it is present in the form of briquettes or pellets.

The procedure of the invention makes it possible for the amount of foamed slag to be held within desired limits, so that the advantageous effect of the foamed slag

2007211649 19 May 2011

can be optimally exploited.

An embodiment of the invention is shown in the drawings.

-- Figure 1 shows an electric arc furnace along sectional line A-B in Figure 2.

-- Figure 2 shows the electric arc furnace along sectional line C-D in Figure 1.

-- Figure 3 shows detail X in Figure 1.

-- Figure 4 shows the height h of the layer of foamed slag as a function of time.

The electric arc furnace 3 illustrated in Figures 1 and 2 is used to melt a metal charge, i.e., to produce a metal bath 2. A layer of slag 1 is located on top of the metal bath 2. In the present case, the slag is to be foamed in order to realize the advantages cited above.

For this purpose, a mixture 4 that contains a metal oxide and carbon is added through suitable feeding devices 7. The mixture may also contain an iron-containing carrier material and a binder. The mixture is preferably compressed into briquettes or pellets. The broken lines running from the feeding devices 7 towards the metal bath 2 indicate how the pellets or briquettes are thrown down onto the surface of the slag or molten metal.

2669315_1 (GHMatters) P78603.AU 12/05/11

2007211649 29 Aug 2008

The specific gravity or compressed density of the mixture 4 is selected in such a way that optimum bubble formation occurs with respect to the intensity of the reaction and the duration of the process. In this regard, the specific gravity is selected in such a way that after the mixture 4 has been introduced into the furnace 3, it stays between the metal bath 2 and the slag 1. This is indicated in Figure 3, which shows that the pellets or briquettes of mixture 4 sink below the foamed slag 1 and float on the metal bath 1.

Further details on this subject may be found in WO 2004/104232 A1.

As Figures 1 and 3 show, the foamed slag 1 has a height h that is to be maintained at a desired value or in a predetermined tolerance range. As specified above, to accomplish this, a suitable amount of mixture 4 is introduced into the furnace 3 per unit time per unit mass of molten metal 2. This can be done continuously or at predetermined time intervals. As indicated in Figure 4, mixture 4 is introduced into the furnace 3 and thus onto the metal bath 2 at regular intervals (see the arrows labeled with reference number 4). Each addition of mixture 4 results in a chemical reaction, the course of which is indicated by the broken curves. The superposition of all reactions results in an overall reaction, which leads to a well-defined height h of the layer of foamed slag. In particular, the height h is maintained within a tolerance range Δh, as indicated in Figure 4.

The intervals of time at which the mixture 4 is added are chosen in a way that ensures bubble formation that is as continuous as possible as a result of the superposition of the individual partial reactions.

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2007211649 29 Aug 2008

In general, it can be said that the reaction of the mixture proceeds nonlinearly, and the foamed slag is formed accordingly. The mixture 4 introduced between the foamed slag 1 and the metal bath 2 is subject to a dissolving process with parallel reduction of the iron oxide. As soon as particles of mixture dissolve out of the pellet or briquette due to the ambient temperature, they become covered with a shell of solidified metal. Due to the fact that the mean melting point of the particle is lower than that of the metal, a melting process and the chemical reactions of the material take place inside the shell. Depending on the temperature difference, the reaction within the shell ends either before or after the melting of the shell. In the former case, the process can lead to bursting of the particle, which results in the explosive liberation of a CO bubble. In the latter case, the CO bubble will evolve freely in the metal.

In this process, the following chemical reaction, for example, takes place:

$$(Fe_xO_y) + y[C] = y\{CO\} + x[Fe]$$

$$(CaCO_3) = (CaO) + \{CO_2\}$$

Optimum results can be obtained if the mixture is added in an amount of 5-15 kg per minute per metric ton (1,000 kg) of molten metal. A mixture that contains 40-70 wt.%, and preferably 50-60 wt.%, of FeCrHC is preferably used.

Figure 2 further shows that the four feeding devices 7 illustrated here feed the mixture onto an annular area of the slag 1 or metal bath 2. The annular area is formed on the radially inner side by the circularly conceived envelope 8 surrounding the electrode 6 or electrodes (inner circle). The outer circle 9 of the annular area is adjacent to the wall 5 of the furnace 3. The mixture is

2007211649 19 May 2011

thus introduced in an annular area between the wall 5 of the furnace and the one or more electrodes 6. In this regard, the mixture 4 is preferably added approximately in the radial center between the inner circle 8 and the outer circle 9, as indicated in Figure 2. In a suitable alternative, additions are made by laterally positioned feeding devices.

The area-specific delivery of a certain weight of mixture has also been recognized as an important parameter. The invention proposes a preferred value for this of 20-30 kg of mixture per square meter of surface area.

An optimum foaming result is thus achieved if, first, a favorable frequency of addition of the mixture is selected (i.e., the amount of mixture per unit time per mass of molten metal), second, the mixture is distributed on the surface of the slag or metal bath in a pattern that is as close as possible to an annular pattern, and, finally, the mixture is added in the specified area-specific amount.

This makes it possible to maintain a desired height of foamed slag as a function of time, which has the aforementioned advantageous effect.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

2669315_1 (GHMatters) P78603.AU 12/05/11

2007211649 29 Aug 2008

List of Reference Symbols

1	slag / foamed slag
2	metal bath
3	metallurgical furnace
4	mixture
5	wall
6	electrode
7	feeding device
8	inner circle (envelope surrounding the electrodes)
9	outer circle
h	height of the foamed slag
Δh	tolerance range of the height h

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2007211649 19 May 2011

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for producing a foamed slag in a metal bath of a metallurgical furnace, in which a mixture that contains at least a metal oxide and carbon is introduced into the furnace, where the metal oxide is reduced by the carbon and where the gases formed during the reduction form bubbles in the slag, thereby foaming the slag, wherein the mixture is introduced into the furnace in such a way that a desired height (h) or a desired range of heights (h) of the layer of foamed slag develops and is maintained, and wherein the mixture is added in an amount of 3-20 kg per minute per metric ton of molten metal in the metal bath.

2. The method in accordance with Claim 1, wherein the mixture is added continuously.

3. The method in accordance with Claim 1, wherein the mixture is added at predetermined intervals of time.

4. The method in accordance with any one of claims 1 to 3, wherein the mixture is added in an amount of 5-15 kg per minute per metric ton of molten metal.

5. The method in accordance with any one of Claims 1 to 4, wherein the mixture is added in such a way that an amount of mixture of 15-35 kg/m^2 is maintained on the surface of the metal bath.

2007211649 19 May 2011

6. The method in accordance with any one of claims 1 to 4, wherein the mixture is added in such a way that an amount of mixture of 20-30 kg/m^2 is maintained on the surface of the metal bath.

7. The method in accordance with any one of Claims 1 to 6, wherein the mixture is introduced between the metal bath and the slag.

8. The method in accordance with any one of Claims 1 to 7, wherein an electric arc furnace or melting unit with electrodes is used as the metallurgical furnace.

9. The method in accordance with Claim 8, wherein, with a wall of the furnace that has an essentially circular design as viewed from above and with an essentially central arrangement of at least one electrode of the furnace, the mixture is added to an annular area between the electrodes and the wall.

10. The method in accordance with Claim 9, wherein the mixture is added in the vicinity of the radial center of the annular area.

11. The method in accordance with any one of Claims 1 to 10, wherein the mixture also contains a carrier material composed of iron and chromium.

12. The method in accordance with any one of Claims 1 to 11, wherein the mixture also contains a binder.

13. The method in accordance with any one of Claims 1 to 12, wherein the mixture is present in the form of

2007211649 19 May 2011

briquettes or pellets.

14. The method in accordance with any one of claims 1 to 13, wherein the metal oxide is reduced by the carbon in the molten metal below the bath.

15. The method in accordance with any one of claims 1 to 14, wherein the mixture is compressed to a density such that the mixture sinks below the slag layer and floats on the metal bath.

16. A method in accordance with claim 11, wherein the carrier of the mixture constitutes from 40-70 wt% of the mixture.

17. The method in accordance with claim 11, wherein the carrier of the mixture constitutes from 40-70 wt% of the mixture and is in the form of FeCrHc.

18. The method in accordance with claim 11, wherein the carrier of the mixture constitutes from 50-60 wt% of the mixture and is in the form of FeCrHc.

19. A method for producing a foam slag in a metal bath of a metallurgical furnace substantially as hereinbefore described with reference to the accompanying figures.

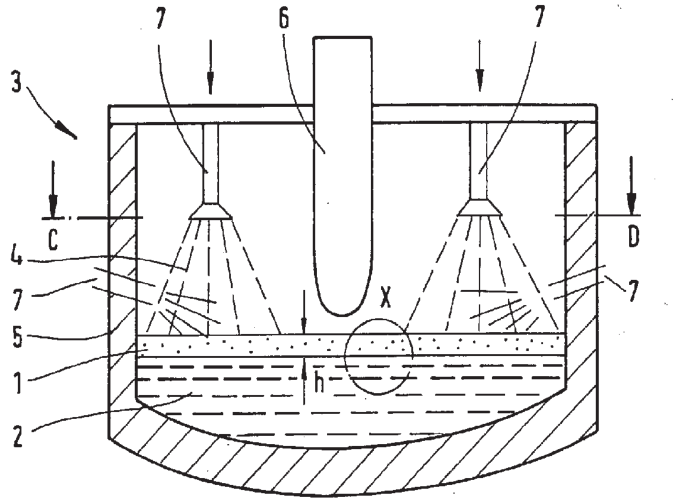

FIG.1

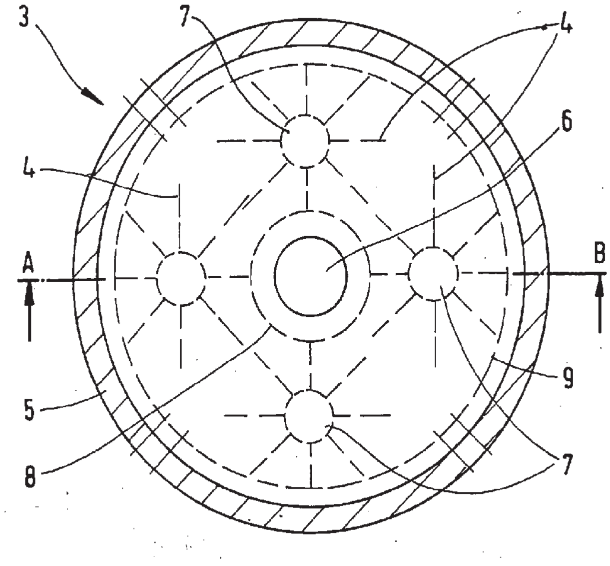

FIG.2

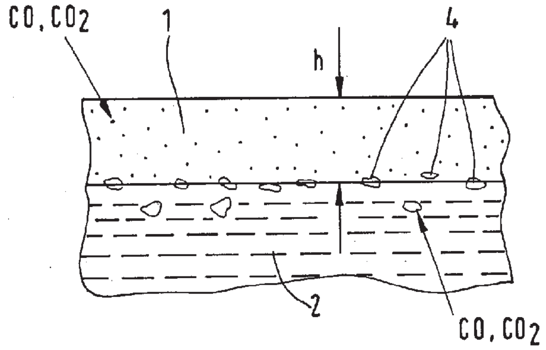

FIG. 3

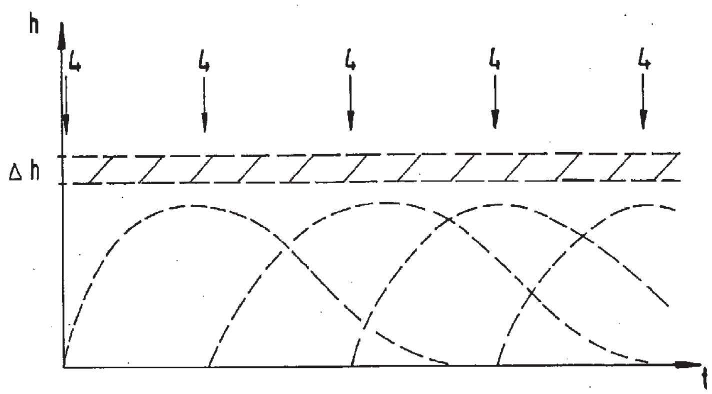

FIG. 4