**Title:** METHOD AND DEVICE FOR DETECTING VARIABLES IN THE OUTLET OF A METALLURGICAL VESSEL

**Abstract:**

With a method for detecting variables in an outlet of a metallurgical vessel, the different variables in the outlet (5) are detected or measured by means of at least one coil (6', 11', 13') surrounding the outlet channel (12) and/or by means of an induction coil (15).
of an induction heater (14) as a monitoring means, wherein the variables preferably relate to the slag portion when pouring out the metal melt, the wear condition of the refractory parts in the outlet channel, the solidified metal melt, the flow rate and/or plugging mass in the outlet channel. As a result, after the evaluation, a closure element for the outlet can be actuated, a heating of the metal in the outlet channel is activated and/or a renewal of the outlet channel is triggered. In this way, an optimum operation in the pouring of metal melt out of a vessel can be simply achieved, wherein the occurrence of irregularities are detected during the entire pouring duration, and the pouring out of slag can be successfully prevented at the end of the pouring.
(54) Title: METHOD AND DEVICE FOR DETECTING VARIABLES IN THE OUTLET OF A METALLURGICAL VESSEL

(54) Bezeichnung: VERFAHREN SOWIE EINE EINRICHTUNG ZUM DETEKTIERN VON GRÖSSEN IM AUSG USS EINES METALLURGISCHEN GEFÄSSES

Fig. 1

(57) Abstract: With a method for detecting variables in an outlet of a metallurgical vessel, the different variables in the outlet (5) are detected or measured by means of at least one coil (6', 11', 13') surrounding the outlet channel (12) and/or by means of an induction coil (15) of an induction heater (14) as a monitoring means, wherein the variables preferably relate to the slag portion when pouring out the metal melt, the wear condition of the refractory parts in the outlet channel, the solidified metal melt, the flow rate and/or plugging mass in the outlet channel. As a result, after the evaluation, a closure element for the outlet can be actuated, a heating of the metal in the outlet channel is activated and/or a renewal of the outlet channel is triggered. In this way, an optimum operation in the pouring of metal melt out of a vessel can be simply achieved, wherein the occurrence of irregularities are detected during the entire pouring duration,

Veröffentlicht:
— mit internationalem Recherchenbericht (Artikel 21 Absatz 3)

and the pouring out of slag can be successfully prevented at the end of the pouring.

METHOD AND DEVICE FOR DETECTING VARIABLES IN THE OUTLET OF A METALLURGICAL VESSEL

The invention relates to a method and a device for detecting of sizes in the spout of a metallurgical vessel according to the preamble to Claim 1 and a device according to Claim 5.

According to the published document EP-A-0 306 792 a device for early detection of slag of a melt stream from a ladle containing molten metal is disclosed, in which a coil is provided, which surrounds a pouring spout under the ladle outlet. This detector coil generates a current, by means of which variations of the electrical conductivity of the outflowing metal melt due to slag are reflected by corresponding variations of the impedance of this detector coil and are measured by the evaluation means. For this purpose, a circuit with signal amplification is provided, which comprises this detector coil and an adjustable capacitor for setting the resonance frequency, so that the capacitive reaction of the circuit due to the presence of this capacitor eliminates the inductive reaction of the circuit, leaving only an impedance as a function of the resistance of the coil.

The object underlying the invention, a method for detecting of sizes in the spout of a metallurgical vessel to improve such that it enables an optimal use with the casting of metal melting and that moreover it is guaranteed the full functional capability of the vessel during the entire pouring process.
According to the invention this object is achieved according to the features of Claim 1 and of Claim 5.

With this method according to the invention, the different variables are detected or measured by means of at least one coil in the spout and/or by means of an induction coil of an induction heater as monitor of the different variables in the spout, wherein it preferably involves the variables of slag proportion during pouring of the metal melt, the degree of wear of the refractory elements in the pouring channel, the solidified metal melt, the flow rate and/or plugging material in the pouring channel. In consequence, a closure member for the spout can be activated, metal in a pouring channel can be heated and/or the pouring channel can be renewed.

Thus, in a simple manner, it is possible to achieve optimum operation during pouring of the metal melt from a vessel, by recognising the occurrence of irregularities throughout the whole pouring period and, moreover, pouring of slag at the end can be successfully prevented.

Furthermore, before or after pouring or when the melt has solidified in spout, it can be established very simply how much solidified melt or plugging material is contained therein.

Likewise, it is possible to detect and determine to what degree the refractory elements forming the spout have worn and at what point in time these will have to be replaced.
In addition, in this way it is also possible to keep the melt in the pouring channel of the spout always hot enough for to prevent solidification before and/or during pouring of the melt or so that metal and/or slag that has possibly solidified in the pouring channel can be melted.

Consequently, even before pouring, with the slide closure in place, melt and/or slag solidified in the pouring channel can be melted even before pouring with the induction coil. The whole pouring procedure is thus carried out more securely and thereby more controllably and, in addition, it is possible to achieve a longer service for the refractory materials of the spout. Accordingly, the use of plugging material and drilling it out or melting of solidified melt or slag with a conventional lance can be avoided.

The invention proposes that the induction heater is composed of an induction coil surrounding the spout and an incorporated cooling system. This measure prevents the induction coil or its ferritic support being heated by brickwork or outer jacket of the furnace and the slide closure when heated in operation.

So that the heat output of the induction coil is concentrated on the pouring channel with as little loss as possible, the invention proposes that the induction coil is embedded in a support of ferritic material and the cooling system is provided with a cooling chamber peripherally surrounding the support as well as a cooling chamber abutting the side wall of the support body directed towards the furnace.
There is a further advantage of the cooling system of the induction coil, that it also enables a deliberate solidification of the melt or slag in the spout of a furnace with a closed slide closure or taphole. This can be detected and indicated accordingly with the coil. For example, this can serve as security against a breakthrough, to ensure safe operation of a furnace between two pouring procedures, which could be important with certain metallurgical furnaces, for example when its spout is situated below the bath level during operation.

The inner casing is provided in the region of the insert with a hard layer that protects the inner surface of the insert, made, for example, of clay material or SiC. The outflowing melt or the slag or the oxidizing gas, such as for example air, is/are thus prevented from attacking the insert. This protective effect may also be extended to the entire inner casing by the hard layer being extended beyond the insert.

In the following the invention is explained in more detail by means of an exemplary embodiment with reference to the drawings. These show as follows:

Fig. 1 a partial cross-section or a partial view of a slide closure according to the invention and the spout of a copper anode furnace;

Fig. 2 a graph with a standardised curve of the current, the complex resistance, the complex angle of the impedance in a coil as a function of the mixture ratio of metal melt to slag according to the abscissa;

Fig. 3 a copper anode furnace according to the invention with a device, illustrated perspective; and

Fig. 4 an enlarged schematic cross-section through an induction heater in the spout according to Fig. 1.
Fig. 1 shows the spout 5 of a metallurgical furnace, preferably a copper-anode furnace 1, which comprises an outer steel cladding 2 and a refractory lining 3. In the lining 3 this spout 5 is formed running radially outwards with a perforated brick 11 with the outlet opening 12.

The slide closure 10, is designed in a conventional manner, as closure system of the outlet opening 12 is arranged at the spout 5. The latter is provided with a housing 9 fastened to the outside of the furnace, into which housing at least one refractory closure plate 6 is inserted and an inner casing 13 adjoining above the latter is fastened detachably. This slide closure 10 additionally has a moveable refractory slider plate 8, as indicated, which is held in a unit (not detailed) and is pressed against the upper closure plate 6 and can be moved relative to the latter into an open or closed position of the slide closure.

On the spout 5 is placed a removable induction heater 14, which has an induction coil 15 surrounding the inner casing 13 above the housing 9. Advantageously, there is assigned to the housing 9 a support ring 23 which is fixed in a holding plate 2' fastened in the steel cladding 2 of the furnace 1.

With the method for detecting variables in the spout 5 of the copper anode furnace 1 it is provided that, by means of at least one coil surrounding the outlet channel 12 and a supply or evaluation unit connected by leads to this, these are measured and evaluated. Thus an alternating current with predetermined frequency is produced by the supply unit in the respective coil and the impedance variations in the variables in the spout 5 and/or the induced current profile are measured by this evaluation unit.
According to the invention, this at least one coil, which is housed in a refractory element forming the pouring channel 12, as in the perforated brick 11, in an inner casing 13, in an annular insert 30, in a closure plate 6 of the slide closure 10, and/or this induction coil 15 surrounding the outlet channel 15 of an induction heater 14 is used, by means of which respectively the at least one, preferably multiple variables are detected or measured for monitoring in the spout, such as the slag proportion during pouring of the metal melt, the degree of wear of the pouring channel, solidified metal melt and/or plugging material in the pouring channel. Furthermore, by this monitoring the flow rate can be determined and also gas inclusions in particular as gas bubbles in the outflowing melt can be assessed.

Following the evaluation, the slide closure 10 can be actuated, heating of the metal in the pouring channel 12 and/or renewal of this pouring channel 12 can respectively take place.

In Fig. 1, in addition to the induction coil 15, as an example, a coil 11' in the perforated brick 11, a coil 13' in the inner casing 13, and a coil 6' in the closure plate 6 are indicated as an example of possible positioning for this monitoring process. It is self-evident that with the method in accordance with the invention, respectively only the induction coil 15, or preferably, in addition, only one of the indicated coils 6', 11', 13' can be used for detection of the different variables in the spout 5 and therewith sufficient results can be obtained. The induction coil 15 can also be used for heating, however.
This respective coil 6', 11', 13' is connected by a lead 34, like that for the lead 26 for the induction coil 15 with an external supply or evaluation unit 33, as can be seen in Fig. 3.

These electrically conducting coils 6', 11', 13' respectively surround the passage opening of the refractory member 6, 11, 13 advantageously coaxially, and are formed from one or preferably multiple windings. They are provided with a lead passing outside the refractory member. They are thus constructed with a sufficient number of windings that adequate measurement conditions can be obtained with them.

Based on the voltage, current and frequency produced in the coil by the supply unit, the complex resistance (Z), the complex angle (ϕ) and/or the current (I) of the impedance.

The measurement conditions of the impedance and/or the induced current profile are determined before, during and/or after pouring in the various conditions, of the proportion of slag in the melt or the wear in the spout 5 and are saved as calibrating reference values, which are compared with the actual measured values during and/or after pouring and the magnitudes are derived from them.

The measurement states of the impedance can also be determined before, during and/or after pouring in the new condition of the spout and during pouring only of metal or only of slag in this new condition of the spout and the actual values are compared and evaluated with this initial condition.
Fig. 2 shows a graph with a standardised curve, not in absolute numbers, of current $[I]$, the complex resistance $[Z]$ and the complex angle $[\varphi]$ of the impedance in a coil as a function of the mixture ratio $m$ of melt to slag. The mixture ratio $m$ is indicated on the abscissa between 0 and 1 of the proportion of metal (copper) from 0 to 100%, while on the ordinate are standardised or ratio values between -1 and +1.

It can be seen that the complex resistance $[Z]$ increases approximately in proportion to the decrease of the metal fraction according to the curve 35 of the alternating current in the coil at 50 Hz. The curves 36 and 37 with the current $[I]$ and the complex angle $[\varphi]$ run approximately symmetrically to the zero line and these vary with the reduction of the proportion of metal, initially very closely and at approximately more than 80% metal fraction the curve transposes into a proportionally smaller decrease towards zero. This confirms that the proportion of slag in the outflowing metal melt can be accurately determined from the impedance.

In order to monitor the at least one, preferably various variables, within the scope of the invention, a temperature measurement is also made in the region of the outlet opening 12 and/or at the induction heater 14. For expediency, at least one sensor is installed in the said region, connected via a lead to the evaluation unit and is used for determination of variables or comparison with reference values and, where there are appropriate deviations, the closure member for the spout can be actuated, metal in the outlet channel can be heated and/or renewal of the outlet channel can be initiated. This attention to the temperature in the spout 5 can also be coordinated or compared with the
determination of the impedance, so that compensation can be made for errors in the measurements.

In order to optimise the heating effect of the induction coil 15 in the outlet channel 12 of the spout an annular insert 30, preferably made of graphite or a material containing graphite, is provided in the inner casing 13 in the region of the induction coil 15. Advantageously, the insert 30 is provided with an insulating layer on the rear side or on both front sides.

The inner casing 13 is provided with a hard layer 31, preferably made of clay Al₂O₃ or SiC, in the region of the insert 30, by means of which layer the inner surface of the insert is protected against the outflowing melt or the slag or oxidizing gas, such as for example air. The hard layer 31 may optionally be extended beyond the annular insert 30. In order to facilitate fitting, the inner casing 13 is centred in the housing 9 and in the spacer ring 24 and is inserted into the perforated brick 11 from the outside.

Fig. 3 illustrates a copper-anode furnace 1 with a slide closure 10 fitted to its spout, which slide closure comprises a furnace drum having a steel cladding 2 and a filling opening 4. The copper melt that is cleaned in the furnace by a special treatment is then poured through the slide closure 10 which is fitted on the spout on the periphery of the furnace drum.

In the copper-anode furnace 1, an external generator 27 and a transformer 28 connected to the latter via lines 25, are preferably provided in the spout for the operation of the induction heater 14, said transformer being attached, for example, to the furnace 1. In addition, this power supply line 26 leading from the transformer 28 to the induction coil 15 as well as the cooling line are provided. The generator and the
transformer could also be formed as one unit and be attached to the furnace or be positioned separately from the latter.

Furthermore, as already explained above, the respective coil 6', 11', 13' is connected by a lead 34 to an external supply or evaluation unit 33, by means of which this detection is made in accordance with the invention. It would also be possible to integrate the supply unit for the coils in the generator 27.

By means of a cooling system 16 having a cooling unit 29 and feed and return lines 20, 21 on the one hand coolant is conveyed into the induction coil 15 and the cooling chambers 18, 19 of the induction heater 14, and on the other hand to the generator 27 and the transformer 28 with sufficient cooling capacity.

The invention can basically also be used in all metallurgical furnaces the spout of which is provided with a slide closure disposed on the end of the spout.

The induction heater 14 according to the invention is activated either manually or automatically in cooperation with the actuation device of the slide closure. Depending on the type or structure of the furnace, a number of induction coils distributed over the length of the spout can be included.

As is evident from Fig. 4, the induction coil 15 is embedded in a supporting body 17 made of ferritic material. The supporting body 17 along with the cooling chambers 18, 19 surrounding it are fitted in the support plate 23. Furthermore, the induction heater 14 is advantageously encased on the rear and side walls with an insulating layer. In addition, a spacer ring 24, preferably made of copper material, is inserted between this supporting body 17 and the slide closure 10. This spacer ring 24 likewise serves to centre the inner casing 13 in the spout 5. However, two separate
rings could also be provided. A longitudinally running line with a groove or the like for receiving at least one line 26, such as a power supply line and a coolant line, for the induction coil 15 is also provided between the support plate 23, the holding plate 2' and the housing 9.

5

The housing 9 is fastened to the support plate 23 or the holding plate 2' and can be separately fitted and removed together and with the inner casing 13 from the induction heater 14 with the supporting body 17, the induction coil 15 and the cooling chambers 18, 19.

10

Instead of a copper anode furnace, it would also be possible to provide other vessels with the slide closure or a like closure device as, for example, a copper converter with a taphole, constructed from several juxtaposed pipes without perforated brick, a flash smelting furnace, an electric melting furnace or similar metallurgical vessel.

15

The method in accordance with the invention for detecting the variables specified is advantageously suited for a spout provided as outlet of a copper converter. The at least one coil is embedded in one of the multiple juxtaposed pipes (tapping bricks) or in an intermediate sleeve as refractory element surrounding them. Where determination is by means of impedance, in particular it is possible to establish the degree of wear of the refractory elements, the solidified metal melt and/or plugging material in the outlet and their condition can be established in a simple manner and where necessary measures can be taken immediately, firstly to replace the refractory members in a worn condition and secondly, to prevent a breakthrough in the converter being at risk due to worn out refractory members.
Within the scope of the invention another closure member can be used instead of a sliding closure, for example a plug closure, by means of which the spout can be opened or closed in a known manner from the inside of the vessel or from outside. A plugging material can also be used as closure member for closing the outlet in a known way from outside, for example one containing aluminium oxide and being deformable.

With an outlet without closure member, for example a free-running nozzle with a tundish, a coil could also be embedded in a refractory member and, using the method in accordance with the invention, at least the wear condition of the refractory member forming the outlet can be determined.
CLAIMS

1. Method for detecting variables in a spout of a metallurgical vessel, with which at least one coil surrounding the outlet opening or channel (12) and a supply or evaluation unit (33) connected with this by leads (34) is measured and evaluated, wherein an alternating current with a predetermined frequency is produced by the supply unit in the respective coil and the impedance or the induced current flow are determined by this evaluation unit from variations in the parameters, characterised in that the at least one coil (6', 11', 13'), which is housed in a refractory member forming the pouring channel, as in the perforated brick (11), in the one or multiple inner casings (13), in an annular insert (30), in a closure plate (6), a slide closure (10) or such, or the induction coil (15) surrounding the outlet opening or channel (12) of an induction heater (14) is used, by means of which the at least one, preferably the different variables in the spout (5) are detected or measured, such as the proportion of slag during pouring of the metal melt, the degree of wear of the refractory parts in the pouring channel, solidified metal melt or plugging material in the pouring channel, and that after the evaluation a closure member for the spout (5) is actuated and heating of the metal in the pouring channel or renewal of the pouring channel can take place.

2. Method in accordance with claim 1, characterised in that measurement states of the impedance or of the induced current flow, during or after the pouring in the various states of the variables, such as the proportion of slag in the melt or the proportion of slag in the spout (5) are estab-
lished or determined and saved as calibrating reference values, which are compared with the actual measured values before, during or after pouring and the values are assigned.

3. Method in accordance with claim 1 or 2, characterised in that the variations of the impedance are determined on the basis of the voltage, current and frequency produced in the coil by the supply unit, wherein the complex resistance (Z), the complex angle (ϕ) and/or the current (I) of the impedance are determined by the evaluation unit.

4. Method in accordance with claim 1 or 2, characterised in that, for monitoring of the at least one, preferably various variables, a temperature measurement is made in addition in the vicinity of the outlet channel (12) and/or the induction heater (14), which is referred to or compared with target values by the evaluation unit (33) for determination of the variables and, where there are deviations, the closure member for the spout (5) is actuated, the metal in the pouring channel is heated and/or the pouring channel is renewed.

5. A Device for the execution of the method according to any of the preceding Claims 1 to 4, with a slide closure unit on the spout of a metallurgical vessel, preferably a copper-anode furnace (1), comprising a housing (9) in which refractory closure plates (6, 8) as well as at least one connecting refractory inner casing (13) are arranged, characterised in that a removable induction heater (14) is provided, having at least one induction coil (15) at least partially surrounding the at least one refractory inner casing (13) outside of or within the housing (9), which is connected via leads to a supply or evaluation
unit (33), wherein induction coil (15) is heated with this or as monitor at least one, preferably various variables in the spout (5) can be detected or measured by the evaluation unit (33).

6. The slide closure unit according to Claim 5, characterised in that the induction heater (14) is provided with an induction coil (15) that has these encasing cooling chambers (18, 19) and that surrounds the spout (5).

7. The slide closure unit according to Claim 6, characterised in that the induction coil (15) is embedded in a supporting body (17) made of ferritic material and is provided with a cooling chamber (18) that encloses the supporting body (17) peripherally and with a cooling chamber adjacent to the side wall of the supporting body directed towards the furnace.

8. The slide closure unit according to Claim 7, characterised in that the supporting body (17), along with the cooling chambers (18, 19) surrounding it, is fitted removably in a support plate (23) fastened to the spout (5), a spacer ring (24) supported against the supporting body (17) being inserted between said support plate and the slide closure (6).

9. The slide closure unit according to any of the preceding Claims 5 to 8, characterised in that the induction coil (15) and the cooling chambers (18, 19) of the induction heater (14) are fed with a coolant by means of a cooling system (16) that has a cooling unit (29) in the vicinity of the furnace.
10. The slide closure unit according to Claim 9, characterised in that solidification of the melt or slag in the spout of a furnace can be achieved with the cooling system (16) of the induction coil.

11. Device in accordance with one of the preceding claims 5 to 10, characterised in that
In addition to the supply and evaluation unit (33) a generator (27) and a transformer (28) are provided for supplying power to the induction coil (15).

12. Device in accordance with one of the preceding claims 5 to 11, characterised in that
the slag reaching the spout at the end of pouring can be detected with the induction coil (15) and the slide closure (10) can be closed automatically.

13. Refractory member for the spout of a metallurgical vessel for carrying out the method in accordance with one of the preceding claims 1 to 4, with an outlet opening, which is constructed as perforated brick, as inner casing (13), as annular insert (30), as closure plate (6) of a slide closure (10) or as similar sleeve,
characterised in that
at least one electrically conducting coil (6', 11', 13') is housed in the refractory member, which surrounds the outlet opening and made from one or preferably multiple windings and provided with or can be connected with a lead, to produce an alternating current in the coil.
14. Refractory member in accordance with claim 13, characterised in that the coil (6’, 11’, 13’) is aligned coaxial to the outlet opening and is preferably constructed with a sufficient number of windings to produce adequate measuring conditions with the same.

15. Refractory member in accordance with 13 or 14, characterised in that it can be applied for a spout (5) of a copper anode furnace (1) or a copper converter.