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(54) **GAS PURGING PLUGS COMPRISING WEAR INDICATORS**

SPÜLKEGEL MIT VERSCHLEISSANZEIGE

BOUCHONS POREUX COMPRENANT DES INDICATEURS D'USURE

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Description

[0001] The present invention relates to refractory purging plugs generally used for blowing gas into a metallurgical vessel. It refers in particular to such purging plugs provided with a wear indicator informing an operator of the level of wear of the purging plug.

BACKGROUND OF THE INVENTION

[0002] In metal forming processes, metal melt is transferred from one metallurgical vessel to another, to a mould or to a tool. For example a ladle is filled with metal melt out of a furnace and transferred to a tundish. The metal melt can then be cast from the tundish to a tool for forming slabs or to a mould for forming billets or ingots. In some cases, it is desirable to blow a gas into the molten metal contained in such metallurgical vessels. This can be useful to accelerate the homogenization of the temperature and composition of a bath, to carry non metallic inclusions present in the bulk of the bath up into the slag top layer, to create favourable conditions within the molten metal, and the like. The gas is generally blown into the molten metal by means of purging plugs located at the bottom or side of a metallurgical vessel such as a ladle or a tundish.

[0003] Purging plugs are in the form of a block of refractory material, generally extending along a longitudinal axis. At one end of the block, a gas inlet connected to a source of pressurized gas is fluidly connected to a gas outlet at the opposite end of the block. The gas inlet and gas outlet may be fluidly connected to one another through an open pore network, by one or more channels (e.g., slit shaped or with circular cross-section), or a combination of both. An open pore network is sometimes said to yield "*indirect permeability*," whilst a channel is said to yield "*direct permeability*." It is generally recognized that direct permeability plugs are more efficient than indirect permeability plugs, mostly because a pore network comprises an uncontrollable tortuosity which affects negatively the permeability of the plug, whilst the size and geometry of a manufactured channel can be controlled such as to minimize tortuosity, and therefore increase the permeability compared with pores of same equivalent diameter or dimensions.

[0004] As illustrated in Figure 1, a purging plug (1) is usually embedded in the wall and lining of a metallurgical vessel (31), with the gas inlet facing the exterior side of the metallurgical vessel, and with the gas outlet facing the inside of the vessel, in contact with the molten metal. The terms "gas inlet" and "gas outlet" being defined with respect to the flow direction (11) of the gas being injected into the metallurgical vessel. Because of their structure and extreme working environment, purging plugs wear more quickly than the refractory liner of the vessel, with severe erosion of the order of several mm or even cm after each use. This means that during the lifetime of a metallurgical vessel such as a ladle, gas plugs need be

changed several times. The changing of a gas plug takes time, is work intensive, and requires the purchase of a new plug each time, so that operators tend to push the use of a plug as long as possible to extend the intervals between plug changes. One major danger with pushing the use of a plug too long, is that if the erosion of the plug is too deep, the remaining base of the plug may be unable to resist the pressure of the molten metal and may leave a gaping hole whence molten metal may flow out freely. If this happens during transfer of the ladle towards a tundish, it may spray molten metal at temperatures of the order of 1400°C all over the workshop with dramatic consequences. To avoid this to happen, wear indicators have been proposed in the art, informing the operator of the degree of erosion undergone by a purging plug, who can decide whether it could be used again or not.

[0005] US5202079 proposes an indirect permeability type plug (i.e., wherein the gasflow path is defined by the porosity of the plug) comprising an outer body defining the external geometry of the plug, said outer body being made of a non-porous refractory material, and an inner core made of a refractory material of higher porosity, allowing gas to flow from an inlet to an outlet of the plug. The transverse cross section of the porous core, normal to the longitudinal axis of the plug, varies along said longitudinal axis. When a metallurgical vessel is emptied of its molten metal load, gas is injected through the plug as it is still hot, and the gas flowing out of the hot plug into the interior of the empty vessel will glow defining the shape of the porous core cross-section exposed to the interior of the vessel giving the operator an indication on the level of erosion of the plug depending on the shape of the glowing section. This system, however, is restricted to indirect permeability type plugs, and reduces the efficacy of the plug by restricting the gas flow path to the inner core of the plug. Another disadvantage of this type of plug is the cooling effect of the gas. The plug gets colder. This increases the wearing but also the risk of metal freezing and clogging of the plug.

[0006] Similarly, US4385752 discloses porous plugs comprising a porous outer body and a porous inner core having a different emissivity than the refractory of the outer body. The principle is therefore quite similar to the previous document, with the difference that the outer body is also porous, thus increasing the efficacy of the plugs with respect to the one disclosed in US5202079. This solution is, however, also restricted to porous plugs only.

[0007] US5249778 extends the principle disclosed in the former two documents to direct permeability plugs, by providing a plug with one or more channels extending from a gas inlet to a gas outlet, and further including a porous insert in fluid communication with the gas inlet, and extending along the longitudinal axis of the plug up to the height corresponding to, or nearly to the end of use of the plug. When erosion reaches the porous insert, gas flowing through the porous insert will cool the refractory centre quicker than the periphery, thus creating a

dark spot at the centre indicative of the end of the plug's service life. Each of the foregoing plugs require gas to be injected through the plug when the vessel is empty, and therefore not necessarily close to a connection to a gas source. The cooling of the plug leads to the drawbacks above mentioned.

[0008] US5330160 discloses a purging plug comprising an insert made of a material having a lower melting point than the metal contained in the vessel, said insert being inserted into a cavity extending from the plug top (which is to contact the molten metal) down to a level of plug considered as indicative of the end of the service life thereof. The low melting point insert can extend up to and is flush with the top end of the plug, or end to a level lower than said top end" the top of the cavity being filled with a top cap made of a high wear resistant refractory material. When the top cap is worn out and the top of the low melting temperature material contacts the molten metal to be cast, the low melting temperature material melts and is replaced in the cavity by molten metal to be cast. When the vessel is emptied, some metal remains in the cavity and glows forming a "magic eye" clearly visible by an operator. When the erosion of the plug reaches the bottom of the cavity, the magic eye disappears and the operator is thus informed that the plug should be replaced. In a variation of the former plug, US5421561 discloses a plug wherein the low melting temperature insert is enclosed in a non-metallic tube acting as thermal insulator to further enhance the glow of the "magic eye". The manufacturing of such plug is rather work intensive, as a cavity needs be drilled into the body of the plug and the insert inserted therein, whilst the space between the cavity walls and the insert must be decreased. One wonders whether the low melting temperature visual wear indicator is needed at all, since all is required is a cavity. Furthermore, this system provides a binary signal, indicative that the plug can be used as long as the magic eye is visible, but it does not inform the operator on the erosion rate of the plug. In practice, to be on the safe side, the operators replace the plug when the magic eye appears.

[0009] The present invention proposes a solution allowing to estimate the erosion rate of the plug, which is very easy and relatively cheap to manufacture.

SUMMARY OF THE INVENTION

[0010] The present invention is defined by the attached independent claims. The dependent claims define preferred embodiments. In particular, the present invention concerns a gas purging plug for blowing gas into a metallurgical vessel comprising:

1. (a) An elongated body made of a first refractory material and extending from a first, inlet end to a second, outlet end over a distance, H, measured along a central longitudinal axis comprising,
2. (b) At least one gas flow path fluidly connecting a gas inlet located at said first inlet end of said elon-

gated body to a gas outlet, located at the opposite second, outlet end;

3. (c) A final visual wear indicator in the form of an elongated core extending from the first inlet end (2a) to a first distance, h1, measured along the central longitudinal axis, which is less than the length, H, of the elongated body, $h1 < H$, said final visual indicator being made of a second refractory material of different visual appearance than the first refractory material at least at a temperature comprised between 800 and 1500°C,

Characterized in that, it further comprises an intermediate visual wear indicator, partially embedded in the final visual wear indicator and extending from an initial distance, h0, to a final distance, h2, from the first, inlet end, wherein $h0 < h1 < h2 < H$, and wherein the intermediate visual wear indicator is made of a third material, permitting to yield a different visual appearance than the first and second refractory materials at least at a temperature comprised between 800 and 1500 °C.

[0011] It is clear that it can be advantageous if the second refractory material of the final visual wear indicator and the third material of the intermediate wear indicator are selected such as to permit to yield a different visual appearance with the first refractory material of the body at temperatures beyond, in particular below, 800 to 1500°C, but since it is desired to have an indication of the level of erosion of the plug without having to cool the vessel down, in most cases it suffices that the visual differences between materials appear in that temperature range.

[0012] The third material of the intermediate visual wear indicator may be a metal, preferably steel, more preferably carbon steel or stainless steel, which at least partly melts in contact with the molten metal to be cast, such that, after emptying of the vessel, leaves some of said metal to be cast in the cavity formed by the removal of the metal visual indicator. Alternatively, the third material of the intermediate visual wear indicator may be a refractory material, preferably selected from the group of silicon carbide, magnesite, alumina, castable $Al_2O_3-SiO_2$, Al_2O_3 , spinel, Al-C, Mg-Cr, preferably Al-C, as long as it yields a different visual appearance from the first and second refractory materials of the plug body and of the final visual wear indicator, respectively, at least at a temperature comprised between 800 and 1500 °C. For better visibility, it is recommended to use an indicator made of metal. The glowing of the metal is clearly visible and eases the job of the operator.

[0013] The second refractory material of the final visual wear indicator may be selected from the group of silicon carbide, magnesite, alumina, castable $Al_2O_3-SiO_2$, Al_2O_3 , spinel, Al-C, Mg-Cr, preferably Al-C, as long as it yields a different visual appearance from the first and, if it applies, the third refractory materials of the plug body and of the intermediate visual wear indicator, respectively, at least at a temperature comprised between 800 and

1500 °C.

[0014] The length, h_2-h_0 , of the intermediate visual wear indicator is preferably comprised between 25 and 150 mm, more preferably between 30 and 100 mm, most preferably, between 40 and 70 mm. The height, h_2 , between the plug base and the top of the intermediate wear indicator is preferably not more than 400 mm, more preferably not more than 300 mm, most preferably not more than 200 mm. The height, $h_1 - h_0$, of the portion of the intermediate visual wear indicator embedded in the final visual wear indicator is preferably comprised between 10 and 75 mm, more preferably, between 15 and 50 mm, most preferably between 20 and 30 mm. Between 20 and 80% of the length of the intermediate visual wear indicator is preferably embedded in the final visual wear indicator; preferably, 40 to 60% of the length thereof is embedded and, more preferably about half of the intermediate visual wear indicator is embedded in the final visual wear indicator. The lower level, h_0 , reached by the intermediate visual wear indicator may be of the order of 100 to 150 mm, preferably 105 to 140 mm, more preferably between 120 and 130 mm.

[0015] To further enhance the visual differences between the two, the intermediate and final visual wear indicators may have a cross-section normal to the central longitudinal axis (X1) of different shapes. In case the intermediate visual wear indicator is made of an electrical conductor, such as a metal, an electric circuit may advantageously be connected to two distinct points of the intermediate indicator, at predetermined heights. A light bulb, LED or the like can be connected to said circuit. When the erosion of the plug reaches the highest electric connection, the circuit is disrupted and the light corresponding to said point switches off, indicating the operator, even before the vessel is emptied, that a certain level of erosion has been reached. This embodiment is particularly suitable for vessels which, contrary to e.g., ladles, are not emptied regularly. For instance, it can give an indication of the level of erosion of a purging plug mounted on a tundish even without emptying the tundish.

[0016] The purging plug of the present invention can be a direct permeability type plug, wherein the gas flow path is in the shape of one or several slots extending from the inlet end to the outlet end of the plug or may alternatively be of the indirect permeability type, wherein the gas flow path is defined by the open porosity of the first refractory material making the body of the plug.

[0017] The present invention also concerns a metallurgical vessel comprising a gas purging plug as discussed above, with the gas outlet in fluid communication with the interior of said vessel. The vessel can be for example a ladle or a tundish.

BRIEF DESCRIPTION OF THE FIGURES

[0018] Various embodiments of the present invention are illustrated in the attached Figures:

Figure 1: shows a purging plug mounted on the bottom floor of a metallurgical vessel.

Figure 2: shows a perspective view of a purging plug according to the present invention showing the intermediate and final visual wear indicators.

Figure 3: shows various transverse cuts of a plug at different levels thereof, illustrating the visual appearance of the plug depending on the level of erosion of the plug.

Figure 4; shows a preferred embodiment of the invention with light indicators of the level of wear of the plug.

DETAILED DESCRIPTION OF THE INVENTION

[0019] As can be seen in Figure 2, a purging plug (1) according to the present invention comprises a body extending along a longitudinal axis (X1) between a gas inlet (3a) at a first end of said body and a gas outlet (3b) at the opposite end of said body, along said longitudinal axis, the gas inlet (3a) being in fluid communication with the gas outlet (3b) via at least one gas flow path. The body is made of a first refractory material. A slit shaped gas flow path (3) is illustrated in Figure 2, defining a direct permeability type plug. In such embodiment the first refractory material of the plug body (1) is substantially non-porous, or at least does not have an open porosity able to form a continuous gas flowpath extending from the gas inlet (3a) to the gas outlet (3b) of the plug. The present invention can also be applied to indirect type plugs, wherein the gas flow path is defined by the open porosity of the first refractory material constituting the body of the plug. A frustoconical body is illustrated in the Figures, but it is clear that the present invention is independent of the outer geometry of the purge body (1), as long as a first longitudinal axis (X1) can be defined.

[0020] A plug according to the present invention comprises at least two visual wear indicators (4, 5) arranged such that they can inform an operator on at least four different levels of erosion of the plug. In particular, it comprises a final visual wear indicator (5) in the form of an elongated core extending from the first inlet end (2a) to a first distance, h_1 , measured along the central longitudinal axis (X1), which is less than the length, H , of the elongated body, $h_1 < H$. The final visual indicator is made of a second refractory material of different visual appearance than the first refractory material at least at a temperature comprised between 800 and 1500°C. The final visual wear indicator (5) of the present invention may be made of a porous second refractory material as disclosed in US4385752, and even comprising the same material as the non-porous first refractory material of the body, but with a higher porosity as disclosed in US5249778. A porous visual indicator requires gas injection there-through to create a visual contrast indicative of the level of erosion. Since the cooling effect of the gas is not desired and a source of gas is not necessarily available when the vessel is empty, it is preferred that the visual

appearance between the final visual indicator and the first refractory material of the body be sufficiently different without the need of blowing gas through the plug. For instance, the first and second refractory materials may have different colours, quite visible with a naked eye and the final visual wear indicator (5) needs not be porous. It is preferred that the visual wear indicator be visible without having to cool the vessel, so that the visual appearance between the first and second refractory materials should be different at least at a temperature comprised between 800 and 1500 °C. It is clear that if the two materials show a different appearance at lower temperatures, it is even better, but in most cases, it suffices that the contrast be visible at high temperatures.

[0021] The final visual wear indicator (5) extends up to a height, h_1 , of the plug measured from the plug base (2a) along the longitudinal axis (X1), which is higher than the lowest admissible level, h_0 , of erosion of the plug. It can be made of any of the following materials: silicon carbide, magnesite, alumina, castable $Al_2O_3-SiO_2$, Al_2O_3 , spinel, Al-C, Mg-Cr. The final visual wear indicator (5) is preferably made of Al-C.

[0022] The purging plug of the present invention comprises an additional, intermediate visual wear indicator (4) made of a third material different from the first and second refractory materials of the plug body (1) and the final visual erosion indicator (5). The third material of the intermediate visual wear indicator (4) must be such that when exposed by erosion, the plug seen from above (i.e., from the interior of the vessel) yields a different visual appearance at the surrounding body (1), at the intermediate visual wear indicator (4), and at the final visual wear indicator (5) when exposed. As illustrated in Figures 2 and 3(e), the intermediate visual wear indicator (4) is in the form of an elongated rod, partially embedded in the final visual indicator (4) with a portion thereof protruding out of it. The intermediate visual wear indicator (4) extends from a height, h_0 , defining a height equal to or slightly above the maximum level of erosion tolerated by the plug, to a height, h_2 , from the base (2a) of the plug, wherein, $h_0 < h_1 < h_2 < H$, wherein H is the total height of the plug.

[0023] This arrangement takes full advantage of the two visual wear indicators, as it permits four levels of erosion to be identified. As illustrated in Figure 3(a)-(d), when the erosion reaches a height, h , of the plug which is above h_2 (=the highest point of the intermediate visual wear indicator), the top surface of the plug as can be seen by an operator observing from above the empty vessel appears like a homogeneous surface of the first refractory material of the plug body (2), as shown in Figure 3(a) (cut A-A). When the erosion reaches a height comprised between h_2 and h_1 (=highest point reached by the final visual wear indicator), the operator can see the cross section of the intermediate visual wear indicator (4) enclosed in the first refractory material of the plug body (2), as shown in Figure 3(b) (cut B-B). When erosion proceeds further between h_1 and h_0 (= bottom end of

the intermediate visual wear indicator), the operator can see three different portions: the surrounding body (2) enclosing the cross section of the final visual wear indicator (5), which itself encloses the intermediate visual wear indicator (4), as shown in Figure 3(c) (cut C-C). Finally, when the erosion proceeds below h_0 , the visual appearance of the top surface of the plug consists simply of the second refractory material of the final visual wear indicator (5) embedded in the surrounding plug's first refractory material (2), as shown in Figure 3(d) (cut D-D). At this point, the plug cannot be used further, lest it would wear off completely during the next operation, leaving a gaping hole where the plug should be.

[0024] The intermediate visual wear indicator (4) can be made of a third refractory material selected out of the same list of materials presented for the second refractory material of the final visual wear indicator (5), as long as it yields a visual appearance at least in a temperature range comprised between 800 and 1500°C, which is different, on the one hand, from the first refractory material of the body (2) of the plug, so that an erosion of the plug to a height comprised between h_2 and h_1 can readily be spotted by visual observation and, on the other hand, from said second refractory material, so that an erosion of the plug between h_1 and h_0 can be identified. The third refractory material can be the same as the first refractory material of the plug body, but with a higher porosity, allowing gas to flow therethrough when the top surface of the intermediate visual wear indicator is exposed to ambient by erosion, and thus cool at a quicker rate than the surrounding body, yielding a darker colour than the latter. Alternatively, the third refractory material can as such be visually distinct from the first and second refractory material. It can for instance be loaded with a pigment, such as carbon black or titanium dioxide, giving a colour different from the first and second refractory materials.

[0025] In an alternative embodiment, the intermediate visual wear indicator can be made of a third material which is not refractory and which actually has a melting temperature lower than the temperature of the molten metal to be contained in the vessel. When the erosion of the plug reaches a height of h_2 , thus exposing the top of the intermediate visual wear indicator (4) to contact with the molten metal at a temperature higher than the melting temperature of the third material, the intermediate visual wear indicator will melt and the cavity left by the molten intermediate visual wear indicator gets filled by the molten metal contained in the vessel. After emptying the vessel, some metal remains in the cavity forming the "magic eye" reported in US5330160. It should be stressed that the final visual wear indicator (5) shall never be made of a low melting temperature material else, upon eroding the plug down to a height h_1 ; the molten metal contacting the top of the final visual wear indicator (5) would melt it and fill the cavity left by it which extends down to the base (2a) of the plug, and flow out of the vessel with dramatic consequences.

[0026] The third, low melting temperature material of

the intermediate visual wear indicator can be selected from the group of soapstone, calcium silicate, talcum, or metal. In a preferred embodiment of the invention, the intermediate visual wear indicator is made of metal, preferably steel, such as carbon steel or stainless steel. The expression "low melting temperature material" is used here to refer to materials having a melting temperature lower than the temperature of the molten metal contained in the vessel.

[0027] Alternatively, the material of the intermediate visual wear indicator does not necessarily present a melting temperature lower than the temperature of the molten metal contained in the vessel. In such a case the material is such that it melts during the cleaning of the plug by oxygen lancing. The cleaning of the plug by oxygen lancing is not always necessary but it helps to better identify the different wear indicators and/or melt some of them.

[0028] The intermediate and final visual wear indicators (4, 5) are in the shape of an elongated prism, of any cross sectional geometry: their cross section may be round, to yield a cylinder, or may be polygonal. If the cross sectional geometries of the intermediate and final visual wear indicators are different from one another, say one is square and the other round, the visual contrast between the two can be even more striking, and any confusion between an erosion down to the height comprised between h_2 and h_1 (i.e., where the intermediate visual wear indicator (4) alone is exposed) and an erosion down to below h_0 (i.e., where the final visual wear indicator (5) alone is exposed) can thus be avoided.

[0029] The intermediate wear indicator (4) typically has a length comprised between 25 and 150 mm, preferably between 30 and 100 mm, more preferably, between 40 and 70 mm. Between 20 and 80% of its length is preferably embedded in the final visual wear indicator (5), more preferably between 40 and 60% of its length, and more preferably, about half of the intermediate visual wear indicator (4) is embedded in the final visual wear indicator (5). A plug can safely be used until at least 100 mm of the plug remains un-eroded. For this reason, the lowest point, h_0 , reached by the intermediate visual wear indicator (4) should be slightly greater than 100 mm, and is preferably comprised between 105 and 150 mm, preferably between 110 and 130 mm.

[0030] If the intermediate visual wear indicator (4) is made of an electric conducting material, such as a metal, it can be advantageous to define an electric circuit (100, 101, 102) connected to at least two distinct points of said intermediate visual wear indicator (4) and further comprising a light (L1, L2, L3) indicating whether the circuit is still operational or is disrupted by the erosion of the plug. Figure 4 shows an example of such embodiment, wherein three parallel circuits are all connected to the lowest point of the intermediate visual wear indicator (4) at a height h_0 , and to three points at different levels of the indicator, a first circuit (102) at the top, h_2 , of the indicator, a second (101) at the height, h_1 , where the intermediate and final visual wear indicators (4, 5) meet,

and a third (100) at the bottom, h_0 , of the indicator (4) but separated from the first connection. Three lights (L1, L2, L3) are connected to each parallel circuit and are lit as long as the circuits are operational. When the erosion reaches the height h_2 at the top of the intermediate visual wear indicator (4), the electric circuit (102) is disrupted and the light (L2) goes off indicating that erosion has reached the height, h_2 . As erosion reaches the height h_1 , the second electric circuit (101) gets disrupted and the light (L1) goes off indicating the erosion reached the level h_1 . Finally when the erosion reaches the bottom of the intermediate visual wear indicator (4) at height h_0 , the third light (L3) goes off as the electric circuit (100) is disrupted. Of course, each parallel circuit can be connected to an electrical switch instead of a light, the switch being kept open as long as current can flow in each electric circuit (100, 101, 102). Each switch is connected to a second circuit comprising a light. When a circuit connection to the intermediate visual wear indicator is disrupted by erosion, the corresponding switch closes the second circuit, lighting the corresponding light. Such external light indicator can be very useful for monitoring the level of erosion of a plug coupled to a metallurgical vessel which is not emptied at short intervals like for example in a tundish. The operator can thus be warned of a dangerous level of erosion of the plug before the tundish has been emptied.

[0031] The purging plugs described above comprise only an intermediate and a final visual wear indicators (4, 5), the former being partly embedded in the latter. It is clear that an additional, third or even a fourth wear indicators can likely be partly embedded in one another, thus giving a finer reading of the erosion rate of the plug. It is believed, however, that a dual indicator plug according to the present invention will fulfil the needs in most applications where such plugs are being used.

[0032] A purging plug according to the present invention can be manufactured very easily and economically. A dual-indicator unit is first manufactured. An intermediate visual wear indicator (4) in the form of an elongated rod or prism, can be placed standing at the bottom of a tool into a cavity of depth corresponding to the portion of the intermediate visual wear indicator (4) sticking out of the final visual wear indicator (5). A slip of the second refractory material is then cast over the rod and is at least partially hardened. Alternatively, a slip of the second refractory material is cast in a prismatic (preferably cylindrical) tool and while still viscous, an elongated rod or prism in a third material is partly submerged into said slip, which is then, at least partially hardened. If an electric circuit is used, the wiring can be embedded in the final visual wear indicator (5) during manufacturing of the dual indicator unit.

[0033] The partly hardened dual-indicator unit is then positioned at the bottom of a tool for producing the plug's body (2). If the plug is of the direct permeability type tool, foils of a material degrading at the firing temperature should be positioned where the slits are to be arranged.

A slip of the first refractory material is then cast over the dual-indicator unit to form the plug's body (2) and the tool can be heated to fire both first and second refractory materials. After firing, the plug can be demoulded and the final process steps can be carried out as well known by any person in the art. Alternatively, the plug can be cast directly into its metallic casing. The heat treatment and process steps can be easily adapted by the person skilled in the art.

[0034] A purging plug according to the present invention gives information on at least four levels of erosion of the plug (as illustrated in Figure 3) by using a simple dual-indicator unit, comprising an intermediate visual wear indicator (4) partly embedded in a final visual wear indicator (5). The simple design of the plug is very easy and economical to produce, quite like a standard plug with no indicator, requiring no labour intensive machining step to drill a cavity to insert a rod therein as in US5330160 or in US5421561. It allows the implementation of a "magic eye" as described in the foregoing documents, with additional functionalities and in a simpler way to produce. The present invention can be implemented in purging plugs of the direct and indirect permeability types alike.

Claims

1. Gas purging plug (1) for blowing gas into a metallurgical vessel comprising:

(a) An elongated body (2) made of a first refractory material and extending from a first, inlet end (2a) to a second, outlet end (2b) over a distance, H, measured along a central longitudinal axis (X1) comprising,

(b) At least one gas flow path (3) fluidly connecting a gas inlet (3a) located at said first inlet end of said elongated body to a gas outlet (3b), located at the opposite second, outlet end;

(c) A final visual wear indicator (5) in the form of an elongated core extending from the first inlet end (2a) to a first distance, h1, measured along the central longitudinal axis (X1), which is less than the length, H, of the elongated body, $h1 < H$, said final visual indicator being made of a second refractory material of different visual appearance than the first refractory material at least at a temperature comprised between 800 and 1500 °C,

Characterized in that, it further comprises an intermediate visual wear indicator (4), partially embedded in the final visual wear indicator (5) and extending from an initial distance, h0, to a final distance, h2, from the first, inlet end (2a), wherein $h0 < h1 < h2 < H$, and wherein the intermediate visual wear indicator (4) is made of a third material, permitting to yield a different visual appearance than the first

and second refractory materials at least at a temperature comprised between 800 and 1500 °C.

2. Gas purging plug according to claim 1, wherein the third material of the intermediate visual wear indicator (4) is a metal, preferably steel, more preferably carbon steel or stainless steel, which at least partly melts in contact with the molten metal to be cast, leaving a cavity containing some of said metal to be cast.
3. Gas purging plug according to claim 1, wherein the third material of the intermediate visual wear indicator (4) is a refractory material, preferably selected from the group of silicon carbide, magnesite, alumina, castable $Al_2O_3-SiO_2$, Al_2O_3 , spinel, Al-C, Mg-Cr, preferably Al-C.
4. Gas purging plug according to any of the preceding claims, wherein the second refractory material of the final visual wear indicator (5) is selected from the group of silicon carbide, magnesite, alumina, castable $Al_2O_3-SiO_2$, Al_2O_3 , spinel, Al-C, Mg-Cr, preferably Al-C, and is different from the intermediate visual wear indicator in case it is made of a refractory material.
5. Gas purging plug according to any of the preceding claims, wherein the length, $h2-h0$, of the intermediate visual wear indicator (4) is comprised between 25 and 150 mm, preferably between 30 and 100 mm, more preferably, between 40 and 70 mm, and the height, h2, between the plug base and the top of the intermediate wear indicator is not more than 400 mm, preferably not more than 300 mm, more preferably not more than 200 mm.
6. Gas purging plug according to the preceding claim, wherein the length, $h1 - h0$, of the portion of the intermediate visual wear indicator (4) embedded in the final visual wear indicator (5) is comprised between 10 and 75 mm, preferably, between 15 and 50 mm, more preferably between 20 and 30 mm.
7. Gas purging plug according to any of the preceding claims, wherein the intermediate and final visual wear indicators (4, 5) have a cross-section normal to the central longitudinal axis (X1) of different shapes.
8. Gas purging plug according to any of the preceding claims, wherein said at least one gas flow path (3) is in the shape of one or several slots extending from the inlet end (2a) to the outlet end (2b) of the plug or is alternatively defined by the open porosity of the first refractory material making the body (2) of the plug.

9. Gas purging plug according to any of the preceding claims, wherein the intermediate visual wear indicator (4) is made of an electric conductive material, such as a metal and wherein an electric circuit (100, 101, 102) is defined between two distinct points of the intermediate visual wear indicator (4), at a level comprised between h_0 and h_2 , said electrical circuit further comprising a light indicator (L1, L2, L3) connected thereto.
10. A metallurgical vessel (31) comprising a gas purging plug according to any of the preceding claims, with the gas outlet (3b) in fluid communication with the interior of said vessel.
11. Metallurgical vessel according to the preceding claim which is a ladle or a tundish.

Patentansprüche

1. Gas-Spülstein (1) zum Einblasen von Gas in einen metallurgischen Behälter, wobei der Gas-Spülstein umfasst:

(a) einen länglichen Körper (2), der aus einem ersten feuerfesten Material besteht und von einem ersten Einlassende (2a) zu einem zweiten Auslassende (2b) über einen Abstand H verläuft, der entlang einer Mittel-Längsachse (X1) gemessen wird, wobei er umfasst:

(b) zumindest einen Gas-Strömungsweg (3), der einen Gaseinlass (3a), der am ersten Einlassende des länglichen Körpers angeordnet ist, mit einem Gasauslass (3b) fluidmäßig verbindet, der am entgegengesetzten zweiten Auslassende angeordnet ist ;

(c) einen optischen End-Verschleißindikator (5), der die Form eines länglichen Kerns besitzt, der sich vom ersten Einlassende (2a) zu einem ersten Abstand h_1 erstreckt, der entlang der Mittel-Längsachse (X1) gemessen wird und kleiner als die Länge H des länglichen Körpers ist, $h_1 < H$, wobei der optische End-Indikator aus einem zweiten feuerfesten Material besteht, das zumindest bei einer Temperatur, die zwischen 800 und 1500 °C liegt, eine andere Optik als das erste feuerfeste Material besitzt;

dadurch gekennzeichnet, dass er weiters einen optischen Zwischen-Verschleißindikator (4) umfasst, der teilweise in den optischen End-Verschleißindikator (5) eingebettet ist und sich vom ersten Einlassende von einem Anfangsabstand h_0 zu einem Endabstand h_2 erstreckt, mit $h_0 < h_1 < h_2 < H$, und wobei der optische Zwischen-Verschleißindikator (4) aus einem dritten Material besteht, das ermöglicht, dass es zumindest bei einer

Temperatur, die zwischen 800 und 1500 °C liegt, zu einer anderen Optik führt, als sie beim ersten und beim zweiten feuerfesten Material auftritt.

2. Gas-Spülstein gemäß Anspruch 1, wobei das dritte Material des optischen Zwischen-Verschleißindikators (4) ein Metall ist, bevorzugt Stahl, mehr bevorzugt Kohlenstoffstahl oder Edelstahl, der zumindest teilweise schmilzt, wenn er mit dem geschmolzenen Metall in Berührung gelangt, das gegossen werden soll, wobei ein Hohlraum zurückbleibt, der einiges Metall enthält, das gegossen werden soll.

3. Gas-Spülstein gemäß Anspruch 1, wobei das dritte Material des optischen Zwischen-Verschleißindikators (4) ein feuerfestes Material ist, das vorzugsweise aus einer Gruppe ausgewählt wird, die umfasst: Siliciumcarbid, Magnesit, Aluminiumoxid, gießbares $Al_2O_3-SiO_2$, Al_2O_3 , Spinell, Al-C, Mg-Cr, vorzugsweise Al-C.

4. Gas-Spülstein gemäß irgendeinem der vorherigen Ansprüche, wobei das zweite feuerfeste Material des optischen End-Verschleißindikators (5) aus einer Gruppe ausgewählt wird, die umfasst: Siliciumcarbid, Magnesit, Aluminiumoxid, gießbares $Al_2O_3-SiO_2$, Al_2O_3 , Spinell, Al-C, Mg-Cr, vorzugsweise Al-C, wobei es sich vom optischen Zwischen-Verschleißindikator unterscheidet, wenn dieser aus einem feuerfesten Material besteht.

5. Gas-Spülstein gemäß irgendeinem der vorherigen Ansprüche, wobei die Länge h_2-h_0 des optischen Zwischen-Verschleißindikators (4) zwischen 25 und 150 mm, bevorzugt zwischen 30 und 100 mm und mehr bevorzugt zwischen 40 und 70 mm liegt und die Höhe h_2 zwischen der Basis des Spülsteins und der Oberseite des Zwischen-Verschleißindikators nicht größer als 400 mm, bevorzugt nicht größer als 300 mm und mehr bevorzugt nicht größer als 200 mm ist.

6. Gas-Spülstein gemäß dem vorherigen Anspruch, wobei die Länge h_1-h_0 jenes Teils des optischen Zwischen-Verschleißindikators (4), der in den optischen End-Verschleißindikator (5) eingebettet ist, zwischen 10 und 75 mm, bevorzugt zwischen 15 und 50 mm und mehr bevorzugt zwischen 20 und 30 mm liegt.

7. Gas-Spülstein gemäß irgendeinem der bisherigen Ansprüche, wobei der optische Zwischen-Verschleißindikator und der optische End-Verschleißindikator (4, 5) einen Querschnitt zur Mittel-Längsachse (X1) besitzen, der unterschiedlich ausgeformt ist.

8. Gas-Spülstein gemäß irgendeinem der vorherigen Ansprüche, wobei der zumindest eine Gas-Strö-

- mungsweg (3) die Form von einem oder mehreren Spalten besitzt, die vom Einlassende (2a) zum Auslassende (2b) des Spülsteins verlaufen, oder alternativ von der offenen Porosität des ersten feuerfesten Materials gebildet wird, aus dem der Körper (2) des Spülsteins besteht.
9. Gas-Spülstein gemäß irgendeinem der bisherigen Ansprüche, wobei der optische Zwischen-Verschleißindikator (4) aus einem elektrisch leitenden Material besteht, wie etwa aus Metall, und wobei ein Stromkreis (100, 101, 102) zwischen zwei verschiedenen Punkten des optischen Zwischen-Verschleißindikators (4) auf einem Niveau zwischen h_0 und h_2 festgelegt ist, wobei dieser Stromkreis weiters einen Leucht-Indikator (L1, L2, L3) umfasst, der mit ihm verbunden ist.
10. Metallurgischer Behälter (31), der einen Gas-Spülstein gemäß irgendeinem der vorherigen Ansprüche umfasst, wobei der Gasauslass (3b) mit dem Inneren des Behälters fluidmäßig in Verbindung steht.
11. Metallurgischer Behälter gemäß dem vorherigen Anspruch, wobei der Behälter eine Gießpfanne oder eine Zwischenwanne ist.

Revendications

1. Bouchon poreux (1) pour envoyer du gaz dans un récipient métallurgique, comprenant:
- (a) Un corps allongé (2) composé d'un premier matériau réfractaire qui s'étend d'une première extrémité, d'admission (2a), à une seconde extrémité, d'évacuation (2b), sur une distance, H, mesurée le long d'un axe central longitudinal (X1) comprenant,
- (b) Au moins une voie d'écoulement de gaz (3) reliant de manière fluide une arrivée de gaz (3a), située à ladite première extrémité d'admission dudit corps allongé, à une évacuation de gaz (3b), située à la seconde extrémité opposée, d'évacuation;
- (c) Un indicateur visuel d'usure final (5) prenant la forme d'une partie centrale allongée qui s'étend de la première extrémité d'admission (2a) à une première distance, h_1 , mesurée le long de l'axe central longitudinal (X1), qui est inférieure à la longueur, H, du corps allongé, $h_1 < H$, ledit indicateur visuel d'usure final étant composé d'un deuxième matériau réfractaire d'apparence visuelle différente du premier, en tout cas à des températures comprises entre 800 et 1500°C,

Caractérisé en ce qu'il comprend un indicateur vi-

- suel d'usure intermédiaire (4), partiellement enfoncé dans l'indicateur visuel d'usure final (5) et qui s'étend d'une distance initiale, h_0 , à une distance finale, h_2 , depuis la première extrémité d'admission (2a), où $h_0 < h_1 < h_2 < H$, et où l'indicateur visuel d'usure intermédiaire (4) est composé d'un troisième matériau permettant de produire une apparence visuelle différente de celle produite par les premier et deuxième matériaux réfractaires, en tout cas à des températures comprises entre 800 et 1500°C,
2. Bouchon poreux selon la revendication 1, pour lequel le troisième matériau de l'indicateur visuel d'usure intermédiaire (4) est un métal, de préférence de l'acier, ou plus préférentiellement de l'acier au carbone ou de l'acier inoxydable, qui fond au moins partiellement au contact du métal en fusion que l'on s'apprête à couler, laissant ainsi une cavité contenant un peu dudit métal sur le point d'être coulé.
3. Bouchon poreux selon la revendication 1, pour lequel le troisième matériau de l'indicateur visuel d'usure intermédiaire (4) est un matériau réfractaire, de préférence sélectionné parmi les éléments du groupe suivant : carbure de silicium, magnésite, alumine, $Al_2O_3-SiO_2$ susceptible d'être coulé, Al_2O_3 , spinelle, Al-C, Mg-Cr, de préférence Al-C.
4. Bouchon poreux selon l'une quelconque des revendications précédentes, pour lequel le deuxième matériau réfractaire de l'indicateur visuel d'usure final (5) est sélectionné parmi ce groupe: carbure de silicium, magnésite, alumine, $Al_2O_3-SiO_2$ susceptible d'être coulé, Al_2O_3 , spinelle, Al-C, Mg-Cr, de préférence Al-C, et diffère de celui utilisé pour l'indicateur visuel d'usure intermédiaire si ce dernier est composé d'un matériau réfractaire.
5. Bouchon poreux selon l'une quelconque des revendications précédentes, dans lequel la longueur, $h_2 - h_0$, de l'indicateur visuel d'usure intermédiaire (4) est comprise entre 25 et 150 mm, préférentiellement entre 30 et 100 mm, encore plus préférentiellement entre 40 et 70 mm, et la hauteur, h_2 , entre la base du bouchon et le sommet de l'indicateur d'usure intermédiaire est inférieure à 400 mm, de préférence inférieure à 300 mm, encore plus préférentiellement inférieure à 200 mm.
6. Bouchon poreux selon la revendication précédente, dans lequel la longueur, $h_1 - h_0$, du tronçon de l'indicateur visuel d'usure intermédiaire (4) enfoncé dans l'indicateur visuel d'usure final (5) est comprise entre 10 et 75 mm, de préférence entre 15 et 50 mm, plus préférentiellement entre 20 and 30 mm.
7. Bouchon poreux selon l'une quelconque des revendications précédentes, dans lequel les coupes trans-

versales perpendiculaires à l'axe central longitudinal (X1) des indicateurs visuels d'usure intermédiaire et final (4, 5) présentent une forme différente.

8. Bouchon poreux selon l'une quelconque des revendications précédentes, dans lequel ladite au moins une voie d'écoulement de gaz (3) est en forme d'une ou de plusieurs fentes qui s'étendent de l'extrémité d'admission (2a) à l'extrémité d'évacuation (2b) du bouchon, ou est alternativement définie par la porosité ouverte du premier matériau réfractaire composant le corps (2) du bouchon. 5
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9. Bouchon poreux selon l'une quelconque des revendications précédentes, dans lequel l'indicateur visuel d'usure intermédiaire (4) est fait d'un matériau électro-conducteur, tel qu'un métal et dans lequel un circuit électrique (100, 101, 102) est défini entre deux points distincts de l'indicateur visuel d'usure intermédiaire (4), à un niveau compris entre h0 et h2, ledit circuit électrique comprenant par ailleurs un indicateur lumineux (L1, L2, L3) connecté à ce dernier. 15
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10. Un récipient métallurgique (31) comprenant un bouchon poreux selon l'une quelconque des revendications précédentes, l'évacuation de gaz (3b) étant en communication fluide avec l'intérieur dudit récipient. 25
11. Récipient métallurgique selon la revendication précédente, qui serait une poche ou un répartiteur. 30

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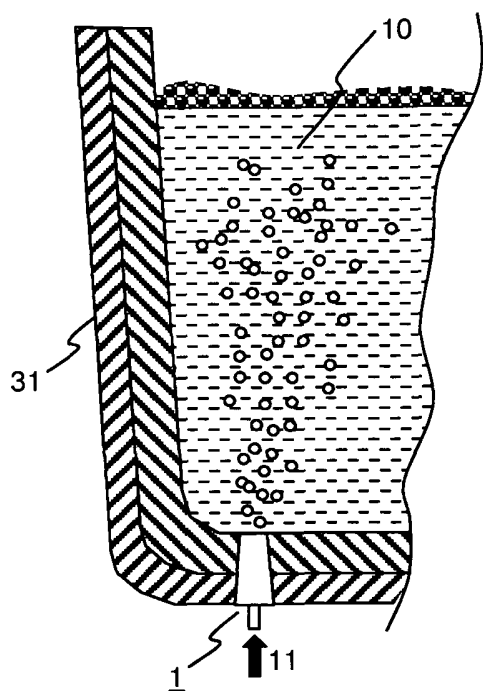


FIGURE 1

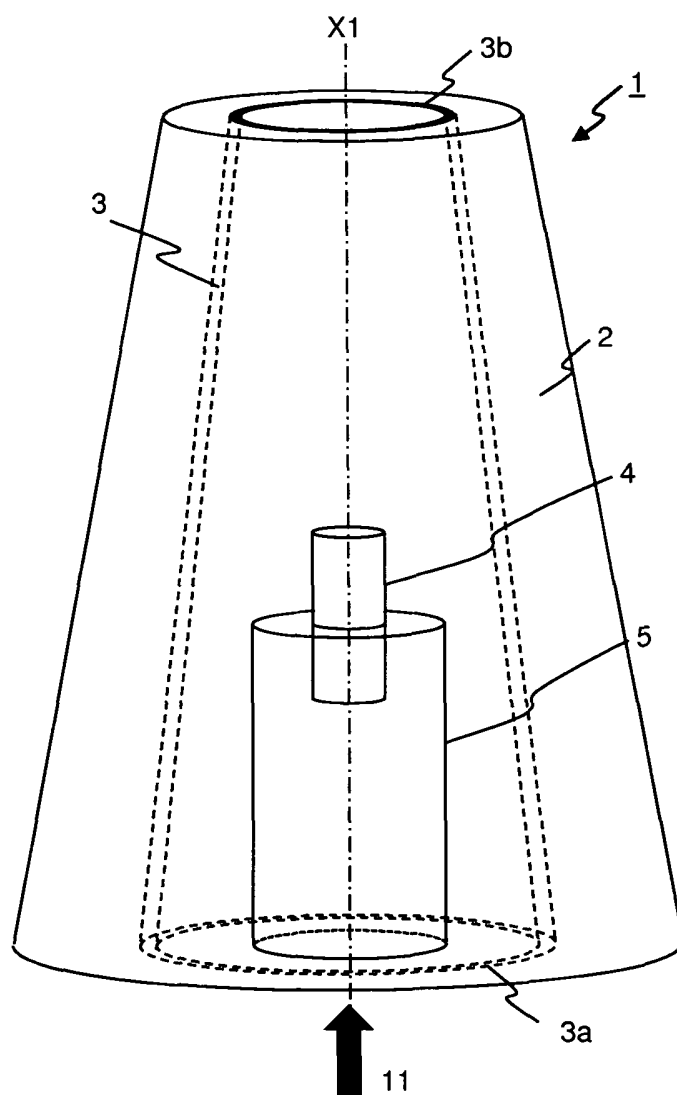


FIGURE 2

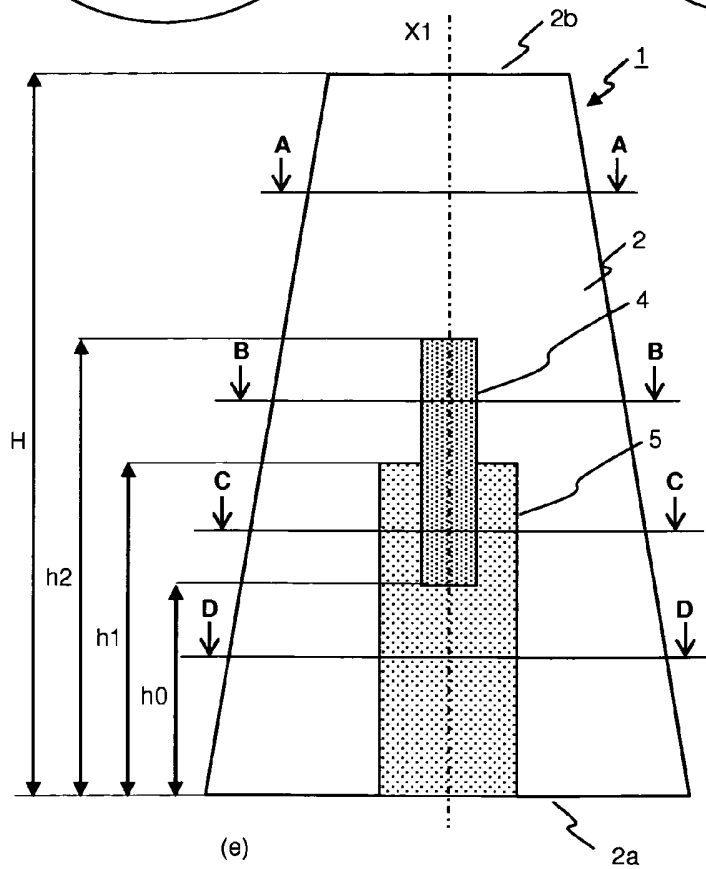
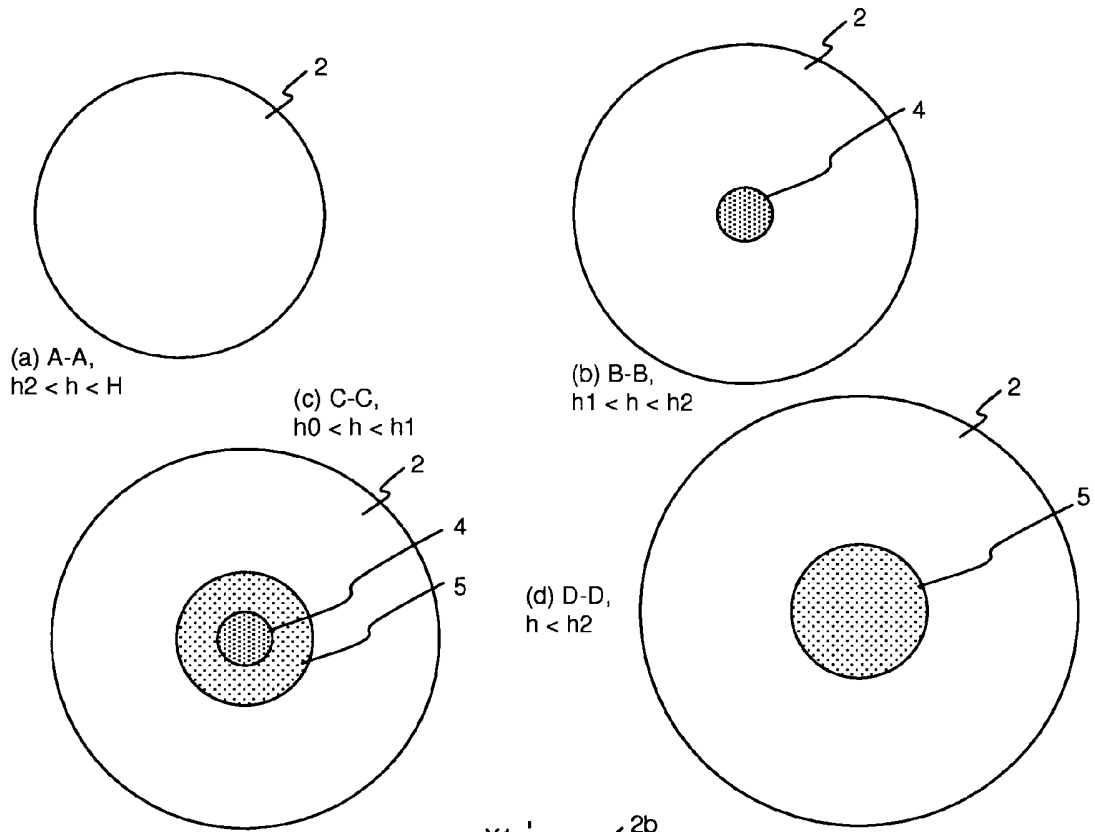


FIGURE 3

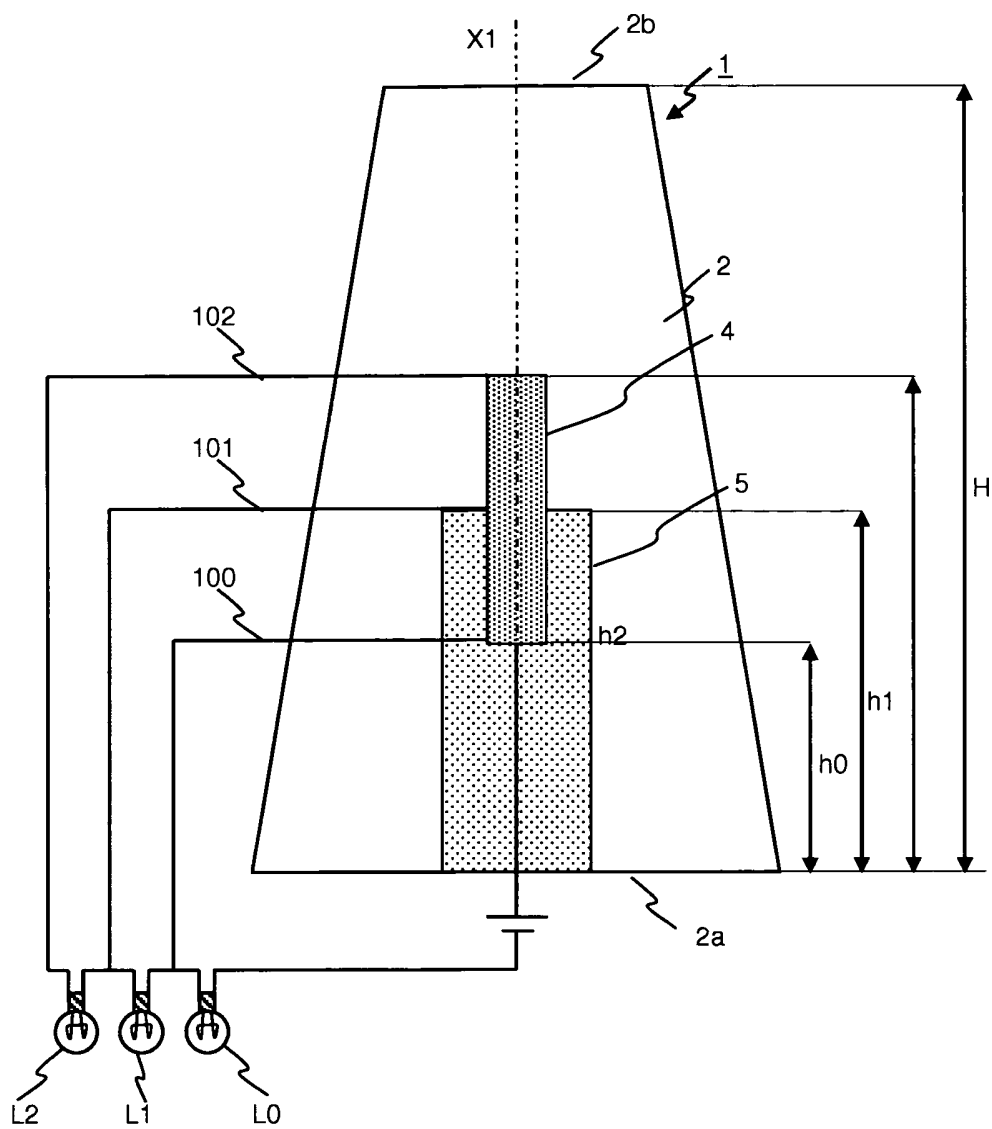


FIGURE 4

REFERENCES CITED IN THE DESCRIPTION

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GÁZÖBLÍTŐTÉGLÁK KOPÁSJELZŐKSEL

SZABADALMI IGÉNYPONTOK

1. Gázöblítőtéglá (1) gáz fémkohászati edénybe történő befúvására, amely öblítőtéglá magában foglal:

(a) egy hosszúkás testet (2), amely egy első tűzálló anyagból készül, és egy első, belépő végtől (2a) egy második, kilépő végig (2b) terjed ki egy központi hossz tengelyen (X1) mért H távolságon át, és magában foglal

(b) legalább egy gázáramlási utat (3), amely fluidumvezető módon összeköt egy, a hosszúkás test első belépő végén elhelyezkedő gázbevezetőt (3a) egy, a szemközti, második kilépő végén elhelyezkedő gázkivezetővel (3b);

(c) egy végső vizuális kopásjelzőt (5) egy hosszúkás mag formájában, amely az első belépő végtől (2a) a központi hossz tengelyen (X1) mért h_1 távolsáig terjed ki, amely kisebb, mint a hosszúkás test H hossza, $h_1 < H$, amely végső vizuális kopásjelző egy második tűzálló anyagból készül, amelynek vizuális megjelenése az első tűzálló anyagétól legalább 800 és 1500 °C közötti hőmérsékleten eltér,

azzal jellemezve, hogy magában foglal továbbá egy közbenső vizuális kopásjelzőt (4), amely részben be van ágyazva a végső vizuális kopásjelzőbe (5), és egy kezdeti h_0 távolságtól egy végső h_2 távolsáig terjed ki az első, belépő végtől (2a), ahol $h_0 < h_1 < h_2 < H$, és amely közbenső vizuális kopásjelző (4) egy harmadik anyagból készül, amely legalább 800 és 1500 °C közötti hőmérsékleten lehetővé teszi egy, az első és második tűzálló anyagétól eltérő vizuális megjelenés biztosítását.

2. Az 1. igénypont szerinti gázöblítőtéglá, amelyben a közbenső vizuális kopásjelzőt (4) alkotó harmadik anyag egy fém, előnyös módon acél, előnyösebb módon szénacél vagy rozsdamentes acél, amely az olvadt öntendő fémmel érintkezve legalább részben megolvad egy üreg képződését okozva, amely bizonyos mennyiséget tartalmaz az öntendő fémből.

3. Az 1. igénypont szerinti gázöblítőtéglá, amelyben a közbenső vizuális kopásjelzőt (4) alkotó harmadik anyag egy tűzálló anyag, amely előnyös módon a következő csoportból kerül kiválasztásra: szilícium-karbid, magnezit, alumínium-oxid, önthető $Al_2O_3-SiO_2$, Al_2O_3 , spinell, Al-C, Mg-Cr, előnyös módon Al-C.

4. Az előző igénypontok bármelyike szerinti gázöblítőtéglá, amelyben a végső vizuális kopásjelzőt (5) alkotó második tűzálló anyag előnyös módon a következő csoportból kerül kiválasztásra: szilícium-karbid, magnezit, alumínium-oxid, önthető $Al_2O_3-SiO_2$, Al_2O_3 , spinell, Al-C, Mg-Cr, előnyös módon Al-C, és különbözik a közbenső

vizuális kopásjelzőtől, amennyiben az tűzálló anyagból készül.

5. Az előző igénypontok bármelyike szerinti gázöblítőtégla, amelyben a közbenső vizuális kopásjelző (4) h2-h0 hossza 25 és 150 mm között, előnyös módon 30 és 100 mm között, előnyösebb módon 40 és 70 mm között van, és a h2 magasság az öblítőtégla alja és a közbenső kopásjelző teteje között nem több, mint 400 mm, előnyös módon nem több, mint 300 mm, előnyösebb módon nem több, mint 200 mm.

6. Az előző igénypont szerinti gázöblítőtégla, amelyben a közbenső vizuális kopásjelző (4) végső vizuális kopásjelzőbe (5) ágyazott részének h1-h0 hossza 10 és 75 mm között, előnyös módon 15 és 50 mm között, előnyösebb módon 20 és 30 mm között van.

7. Az előző igénypontok bármelyike szerinti gázöblítőtégla, amelyben a közbenső és a végső vizuális kopásjelzőnek (4, 5) a központi hossz tengelyre (X1) merőleges keresztmetszete eltérő alakú.

8. Az előző igénypontok bármelyike szerinti gázöblítőtégla, amelyben a legalább egy gázáramlási út (3) egy vagy több, az öblítőtégla belépő végétől (2a) a kilépő végéig (2b) kiterjedő rés alakjában van, vagy pedig azt az öblítőtégla testét (2) képező első tűzálló anyag nyitott porozitása határozza meg.

9. Az előző igénypontok bármelyike szerinti gázöblítőtégla, amelyben a közbenső vizuális kopásjelző (4) villamosan vezető anyagból, például fémből készül, továbbá a közbenső vizuális kopásjelző (4) két eltérő pontja között van egy áramkör (100, 101, 102) h0 és h2 közötti magasságban, amely áramkör magában foglal továbbá egy hozzá kapcsolt fényjelzőt (L1, L2, L3).

10. Fémkohászati edény (31), amely magában foglal egy, az előző igénypontok bármelyike szerinti gázöblítőtéglat, amelynek gázkivezetője (3b) fluidumvezető összeköttetésben van az edény belsejével.

11. Az előző igénypont szerinti fémkohászati edény, amely egy üst vagy egy közbenső üst.

(A meghatalmazott)

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