(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 111 938 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.10.2009 Bulletin 2009/44

(51) Int Cl.:
B22D 1/00 *(2006.01)* ***C21C 5/48*** *(2006.01)*

(21) Application number: **08155102.0**

(22) Date of filing: **24.04.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicant: **Calderys France**
51120 Sézanne (FR)

(72) Inventors:
- **Reichert, Norbert**
  56564 Neuwied (DE)
- **Tassot, Patrick**
  56564 Neuwied (DE)

(74) Representative: **Weihs, Bruno Konrad**
Haseltine Lake LLP
Lincoln House, 5th Floor
300 High Holborn
London WC1V 7JH (GB)

(54) Purging plug for blowing gas into a metal treatment recipient

(57) A purging plug (1) for blowing gas to be attached to an opening (41) of a molten metal treatment recipient, comprises a core (2) having a shape extended along a longitudinal axis (40) from a bottom side (5) to a top side (6), wherein the core is substantially made of a first material, wherein the first material has a first permeability, and a surrounding layer (4) arranged around the core in direction of the longitudinal axis from the bottom side to the top side, wherein the surrounding layer is substantially made of a second material, wherein the second material has a second permeability, the second permeability being of higher value than the first permeability. The purging plug further comprises at least one gas passage duct (7) allowing a gas to flow through the gas passage duct from the bottom side to the top side, the gas passage duct being formed according to one of the following configurations: the at least one gas passage duct is formed as an interstice (7) between the core and the surrounding layer; the at least one gas passage duct is formed as a channel (308) in the core; or the at least one gas passage duct is formed as an interstice between the core and the surrounding layer and at least a further gas passage duct is formed as a channel in the core.

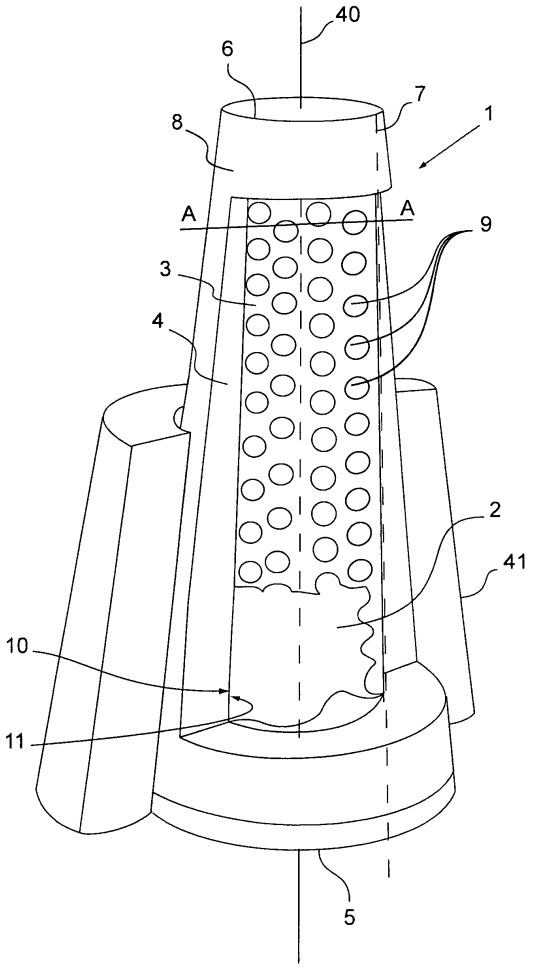

FIG.1

EP 2 111 938 A1

Description

Technical field

[0001] The present invention relates to a purging plug typically used to blow gas into a metal treatment recipient. The present invention further relates to a method for producing the purging plug.

Background Art

[0002] Purging plugs are commonly known in the metallurgical industry as a means to blow gas into a metal treatment recipient containing molten metal. Such recipients are also known for example as metal treatment ladles.

[0003] The gas blown into the metal treatment recipient may allow stirring the molten metal. However other uses of the gas may also be considered. As an example it is known to use the effect of nitrogen in non ferrous metallurgy, by introducing nitrogen gas directly into the liquid metal.

[0004] The purging plug is embedded in a lining of the metal treatment recipient, and a gas supply is connected to a bottom side of the purging plug facing outside of the metal treatment recipient.

[0005] Purging plugs may also find use in transfer ladles, tundishes, or indeed in any other type of molten metal recipient.

[0006] The positioning of the purging plug into a lining of the treatment recipient, transfer ladle, tundish or molten metal recipient may be anywhere, e.g., in the bottom or on the side of the recipient.

[0007] A purging plug may comprise one or a plurality of purging elements whereby a purging element may be either of the direct permeability of indirect permeability categories depending on its properties in terms of letting gas flow through the purging element; a direct permeability category purging element allows for gas flow through a channel from a bottom side of the purging element to a top side of the purging element, while an indirect permeability category purging element allows for gas to get through the permeable structure and other permeability making up the purging element.

[0008] Purging plugs having mainly one or more direct permeability purging elements typically allow to achieve a better performance than purging plugs having mainly one or more indirect permeability purging elements. This may be expressed also in terms of better efficiency, i.e., improved heat and treatment time characteristics for direct permeability purging plugs.

[0009] The downside of purging plugs with direct permeability is that low viscosity metals may easily clog them, i.e., there may be molten metal infiltration in the absence of a transient counter pressure of gas being injected at the bottom side of the purging plug. If the counter pressure of gas is interrupted, one or a plurality of channels in the direct permeability elements may be infiltrated from the top side over several centimeters with molten metal from the treatment recipient. This may happen even in case a thickness of the channels, i.e., an opening of the channels is of relatively small size.

[0010] The problem of clogged channels in a purging plug may under circumstances be solved by injecting gas under high pressure at the bottom side of the purging plug. The high pressured gas may allow a crack to develop in the purging plug and to physically break off along the crack a part of the purging plug containing clogged ends of the channels. This has at least 2 inconveniences. The first inconvenience is unreliability because the crack will not always develop, and if it develops it might not develop along a desired part of the purging plug. The second inconvenience is a degradation of the purging plug because a cracked purging plug has different overall characteristics than the initial purging plug, and thus the performance of the purging plug may be seriously affected by the crack.

[0011] Purging plugs made mainly from one or a plurality of indirect permeability purging elements suffer less from molten metal infiltration. If metal infiltrates this will normally not affect more than a few millimeters of the purging plug. Although such an infiltration inevitably produces a discontinuity in operating the purging plug, this remains minimal and normal operation of the purging plug can be resumed by reinjecting gas at any time.

[0012] One disadvantage of indirect permeability purging plugs is inherent to the permeable structure of the material making up the purging element(s). The permeable structure of course enables gas to transit through the purging element. But the permeable structure also has certain mechanical weaknesses as compared to certain non-permeable or less-permeable structures consisting of dense material. One consequence of the mechanical weakness may be the accelerated abrasion of the permeable material as compared to dense material. Another consequence is the lower resistance to liquid oxidizing phases at high temperatures, which occurs during lance oxygen cleaning, a common procedure in metal treatment recipients.

Summary of invention

[0013] In a first aspect the invention provides a purging plug for blowing gas to be attached to an opening of a molten metal treatment recipient. The purging plug comprises a core having a shape extended along a longitudinal axis from a bottom side to a top side, wherein the core is substantially made of a first material, wherein the first material has a first permeability. The purging plug further comprises a surrounding layer arranged around the core in direction of the longitudinal axis from the bottom side to the top side, wherein the surrounding layer is substantially made of a second material, wherein the second material has a second permeability, the second permeability being of higher value than the first permeability. At least one gas passage duct allows a gas to flow

through the gas passage duct from the bottom side to the top side. The gas passage duct is formed according to one of the following configurations:

- the at least one gas passage duct is formed as an interstice between the core and the surrounding layer,
- the at least one gas passage duct is formed as a channel in the core,
- the at least one gas passage duct is formed as an interstice between the core and the surrounding layer and at least a further gas passage duct is formed as a channel in the core.

[0014] In a preferred embodiment the purging plug further comprises at least one convex projection formed on an external surface of the core facing the surrounding layer, and a concave cavity formed on a internal surface of the surrounding layer facing the core, wherein the concave cavity fits the at least one convex projection, and the convex projection forms a bridge that secures the core from moving relative to the surrounding layer in direction of the longitudinal axis.

[0015] In a further preferred embodiment the purging plug further comprises at least one convex projection formed on an external surface of the core facing the surrounding layer, wherein the convex projection extends as a bridge to be in contact with the surrounding layer.

[0016] In yet a further preferred embodiment the purging plug further comprises at least one convex bulge formed on an internal surface of the surrounding layer facing the core, and a concave recess formed on an external surface of the core facing the surrounding layer, wherein the concave recess fits the at least one convex bulge, and the convex bulge forms a bridge that secures the core from moving relative to the surrounding layer in direction of the longitudinal axis.

[0017] In an other preferred embodiment the purging plug further comprises at least one convex bulge formed on an internal surface of the surrounding layer facing the core, wherein the convex projection extends as a bridge to be in contact with the core.

[0018] In a further preferred embodiment of the purging plug, the shape of the core substantially corresponds to a solid cylinder extending along the longitudinal axis, and the surrounding layer is dimensioned such that the purging plug takes an overall conical shape having its larger base diameter located at the bottom side and its smaller top diameter located at the top side.

[0019] In a further preferred embodiment of the purging plug a thickness of the interstice measured in a direction perpendicular to the longitudinal axis is between 0,1 and 0,5 mm.

[0020] In a further preferred embodiment the purging plug further comprises a casing, whereby the casing encloses the core and the surrounding layer.

[0021] In a second aspect, the invention provides a metal treatment recipient having an opening with a purging plug according the first aspect, or any preferred embodiment thereof, inserted therein.

[0022] In a third aspect the invention provides a method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient. The method comprises steps of providing a foil with a plurality of apertures distributed over a surface of the foil, providing a purging plug casing, and creating with the foil a hollow body inside the purging plug casing such as to separate an inner volume of the purging plug casing into a first volume corresponding to a desired shape of a core, and a second volume being located between the foil and a wall of the purging plug casing. The method further comprises casting a first material having a first permeability into the first volume in order to obtain the core, and casting a second material having a second permeability, the second permeability being of higher value than the first permeability, into the second volume in order to obtain a surrounding layer located around the core, the casting of the second material being done substantially simultaneously with the casting of the first material. The purging plug casing is fired at a temperature sufficient to harden the core and the surrounding layer, and to burn the foil. The foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

[0023] In a fourth aspect, the invention provides a method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient, that comprises steps of providing a purging plug casing, providing a core of the purging plug, whereby the core is made substantially of a first material having a first permeability, and positioning the core inside the purging plug casing, thereby defining a second volume inside the purging plug casing, the second volume being located between the core and a wall of the purging plug casing. The method further comprises casting a second material having a second permeability, the second permeability being of higher value than the first permeability, into the second volume in order to obtain a surrounding layer located around the core, and firing the purging plug casing at a temperature sufficient to harden the surrounding layer.

[0024] In a preferred embodiment of the inventive method further comprises, before the casting of the second material, providing a foil with a plurality of apertures distributed over a surface of the foil, wrapping the foil around the core, and, after the casting of the second material, firing the purging plug casing at a temperature sufficient to harden the surrounding layer and to burn the foil. The foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

[0025] In a further preferred embodiment of the inventive method the core comprises at least a channel, the channel creating a gas passage duct for the blowing of

gas.

[0026] In a fifth aspect the invention provides a method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient, whereby the purging plug comprises a core and surrounding layer arranged around the core. The method comprises steps of providing the surrounding layer, whereby the surrounding layer is made substantially of a second material having a second permeability, and the surrounding layer defines an inner volume to receive the core, casting a first material having a first permeability, the second permeability being of higher value than the first permeability, into the inner volume in order to obtain the core, and firing the purging plug casing at a temperature sufficient to harden the core.

[0027] In a preferred embodiment, the method further comprises, before the casting of the first material, providing a foil with a plurality of apertures distributed over a surface of the foil, wrapping the foil on a wall of the inner volume, and, after the casting of the first material, firing the purging plug casing at a temperature sufficient to harden the core and to burn the foil. The foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

[0028] In a further preferred embodiment of the method, the core comprises at least a channel, the channel creating a gas passage duct for the blowing of gas.

[0029] In a further preferred embodiment of the purging plug or the method, the first material is a dense refractory material that has an open porosity less than 30% measured after the EN1402 norm, and has a gas permeability by argon less than 10 Nanoperm, and the second material is a porous refractory material that has an open porosity more than 30% measured after the EN1402 norm, and has a gas permeability by argon higher than 10 Nanoperm.

Brief description of the figures

[0030] The invention will be better understood in the light of examples of preferred embodiments described hereunder and with reference to Figures, whereby

Fig. 1 contains a schematic representation of an example purging plug according to the invention;

Fig. 2 illustrates a cross section of the purging plug shown in Fig. 1 along line AA;

Fig. 3 contains a flowchart illustrating a method for producing a purging plug according to a preferred embodiment of the invention;

Fig. 4 contains a flowchart illustrating a further preferred embodiment of the method shown in Fig. 3;

Fig. 5 illustrates a cross section of a purging plug according to a preferred embodiment of the invention;

Fig. 6 contains a flowchart illustrating a method for producing a purging plug according to a preferred embodiment of the invention;

Fig. 7 contains a flowchart illustrating a further preferred embodiment of the method shown in Fig. 6;

fig. 8 contains a flowchart illustrating a method for producing a purging plug according to a preferred embodiment of the invention.

Detailed description of preferred embodiments

[0031] The present invention relates to a purging plug that cumulates among others the advantages of both direct permeability and indirect permeability purging elements. The present invention in particular has a structure that avoids a clogging of the purging plug, which in prior art occurs by infiltration of molten metal.

[0032] Fig.1 illustrates a purging plug 1 according to an example of embodiment of the present invention. The purging plug 1 comprises a core 2 surrounded from a foil 3, which on turn is surrounded by a surrounding layer 4. The purging plug 1 may be used for blowing gas into an opening of a molten metal treatment recipient 41 (only shown in part in Fig. 1).

[0033] The core 2 is made of a first material having a first permeability. The first material qualifies as a non-permeable material in the sense that it substantially avoids gas passing through. It may preferably consist of a relatively dense and castable substance.

[0034] The core 2 has a shape extending along a longitudinal axis 40 from a bottom side 5 to a top side 6 of the purging plug 1.

[0035] The foil 3 shown in Fig. 1 typically consists of plastic material, which completely burns away without leaving any remains when the purging plug is exposed to a high temperature. The plastic material may for example be PVC (Polyethylene Vinyl Chloride) or simply polyethylene. The high temperature is typically obtained when the purging plug is fired, for example for the purpose of hardening the core 2 and/or the surrounding layer 4. The high temperature may for example lie above 300°C. In order to reach the high temperature of at least 300°C throughout the purging plus in order to eliminate the foil, the purging plug is fired at a temperature of about 500°C.

[0036] The reason for applying a foil 3 on the core 2 is for obtaining at least one interstice 7 (shown in a dotted line in Fig. 7), which lies between the core 2 and the surrounding layer 4. The interstice 7 which is formed once the foil 3 is burned away, is a gas passage duct that allows a gas (not shown in Fig. 1) to flow through it from the bottom side 5 to the top side 6.

[0037] A thickness of the foil 3 allows to adjust a size of the interstice 7, and more particularly a thickness of

the interstice 7 measured in a direction perpendicular to the longitudinal axis 40. The thickness of the interstice 7 measured in this fashion preferably has a value in a range between 0,1 mm and 0,5 mm. The thickness of the interstice 7 has an influence on a flow rate of gas passing through the interstice 7. The thickness of the interstice 7 may also be chosen depending on a viscosity of molten metals (not shown in Fig. 1) to be treated in the metal treatment recipient.

[0038] The interstice 7 shown in Fig. 1 is only one example of possible gas passage ducts, and its structure allowing a gas to flow from the bottom side 5 to the top side 6 is not limited to the example shown in Fig. 1. There may in fact be one or a plurality of interstices, whereby each such interstice may or may not be connected to another interstice. Hence it is possible to plan a total gas flow rate through the purging plug 1 by selecting an appropriate number of interstices having a determined thickness. In particular the foil 3 need not surround the whole core 2. The foil 3 may be a strip or a plurality of distinct strips.

[0039] The surrounding layer 4 is made from a second material having a second permeability. The second material qualifies as a permeable material in the sense that it allows gas to pass through the surrounding layer, in particular from the bottom side 5 to the top side 6 of the purging plug 1. The surrounding layer 4 is arranged around the core 2, and around the foil 3 while such foil is not yet burned away.

[0040] The second material making up the surrounding layer 4 may be of similar nature as the first material making up the core 2, with the difference that a value of the second permeability is of higher value than the first permeability, i.e., for example that a grain size of the second material and a distribution of the grain size inside the material be chosen such to obtain a desired permeability to gas.

[0041] Preferably the grain size in the second material, and hence the permeability of the second material is adjusted in a compromise to also achieve a determined mechanical resistance. The grain size and distribution inside the material may be adjusted for example to obtain a porosity in a range from 30% up to 70%.

[0042] Hence, preferably the second material is a porous refractory material that has an open porosity more than 30% measured after EN1402 norm, and a gas permeability by argon higher than 10 Nanoperm ($10^{-9}.cm^2$). It will be understood that the overall permeability of the surrounding layer 4 is dependent from the size of the surrounding layer 4, but also of the temperature and the type of gas used.

[0043] The second material may be of castable nature in a manner that the surrounding layer 4 is obtainable through casting of such second material.

[0044] Preferably the first material is a dense material, i.e., a refractory material that has an open porosity less than 30% measured after EN1402 norm, and a gas permeability by argon less than 10 Nanoperm ($10^{-9}.cm^2$). It will be understood that the overall permeability of the core 2 is dependent from the size of the core 2, but also of the temperature and the type of gas used.

[0045] An assembly comprising the core 2 and the surrounding layer 4 may be enclosed in a casing 8, which is preferably made of metal.

[0046] A total shape of the purging plug 1, including or not including the casing 8 may for example be conical, wherein the bottom side has a diameter greater than a diameter of the top side. This is the example illustrated in Fig. 1. However, the example illustrated in Fig. 1 does not constitute a limitation to the present invention, and other total shapes are possible for the purging plug 1. It may for example be possible to have cylindrical, square or star shaped cross sections of the total shape.

[0047] The shape of the core 2 itself may also vary depending for example on external use parameters. The shape of the core 2 may be cylindrical as shown in the example of Fig. 1, whereby a diameter of the core 2 at the bottom side 5 is substantially equal to a diameter of the core at the top side 6. The shape of the core 2 may also the conical, in an alternative embodiment of the invention. In further alternative embodiments, the cross section of the core 2 may be square or star shaped or have any other convenient shape.

[0048] The first material making up the core 2, and / or the second material making up the surrounding layer 4 may for example be constituted from alumina, alumina-spinel, alumina carbon or other basic materials well known from a person skilled in the art.

[0049] The structure of the purging plug 1 combines the advantages of materials having direct permeability and materials having indirect permeability. In particular, the inventive purging plug 1 inherently has the advantage of high gas flow rates and improved efficiency that are characteristic of material with direct permeability. This is due to the one or plurality of interstices 7. At the same time, even if an interstice 7 is infiltrated by molten metal, the gas can continue to flow through the second material of the surrounding layer 4. The circulation of gas through the second material has the effect of heating up the surroundings of the interstices 7 and of any infiltrated metal therein (not shown in Fig. 1). The infiltrated metal heated this way softens and may more easily be removed with over-pressured gas. However, the over-pressure required is generally lower than high pressures of gas required in purging plugs with direct permeability as known from prior art. The lower pressure required to remove the softened infiltrated metal avoids most damages such as breaking off and resulting shortening of the purging plug 1, as they would occur in prior art.

[0050] The purging plug according to the invention has a core of first material, i.e., substantially non-permeable material, that gives to the purging plug an overall improved mechanical stability. In case of lance cleaning in the metal treatment recipient, the purging plug embedded in the lining thereof will experience the effect of cleaning mainly on the top side of the core. The top side of the

core has a better resistance to the corrosion induced by the highly oxidized and very hot developing phases from the lance cleaning.

[0051] In the example shown in Fig. 1, the foil 3 comprises one or a plurality of apertures 9. The apertures 9 allow to achieve bridges of first material or second material for an improved anchoring of an external surface 10 of the core 2 facing the surrounding layer 4, and an internal surface 11 of the surrounding layer 4 facing the core 2. The apertures 9 may be filled either by first material from the core 2, or by second material from the surrounding layer 4. The apertures 9 are filled for example during a casting process of the respective first and second materials.

[0052] Although illustrated in Fig. 1, the one or plurality of apertures 9 constitute an optional feature of the inventive purging plug 1. The one or plurality of apertures 9 may also be omitted and other ways of anchoring the core 2 and the surrounding layer 4 may be used in alternative embodiments, without being disclosed herein.

[0053] In the example illustrated in Fig.1, the apertures 9 may for example be filled in one of the following manners or with a combination thereof:

i. the one or plurality of apertures 9 are filled by one or a plurality of corresponding convex projections formed on the external surface 10 of the core 2. One or a plurality of corresponding concave cavities are formed on the internal surface 11 of the surrounding layer 4 facing the core, whereby each concave cavity fits the corresponding convex projection, and each convex projection forms a bridge that secures the core 2 from moving relative to the surrounding layer 4 in direction of the longitudinal axis 40;

ii. the one or plurality of apertures 9 are filled by one or a plurality of corresponding convex projections formed on the external surface of the core 2 facing the surrounding layer 4, wherein the one or plurality of convex projections extend as bridges to be in contact with the surrounding layer 4;

iii. the one or plurality of apertures 9 are filled by one or a plurality of corresponding convex bulges formed on the internal surface 11 of the surrounding layer 4 facing the core 2. One or a plurality of corresponding concave recesses are formed on the external surface 10 of the core 2 facing the surrounding layer 4, whereby each concave recess fits the corresponding convex bulge, and each convex bulge forms a bridge that secures the surrounding layer 4 from moving relative to the core 2 in direction of the longitudinal axis 40;

iv. the one or plurality of holes 9 are filled by one or a plurality of corresponding convex bulges formed on the internal surface 11 of the surrounding layer 4 facing the core 2, whereby the convex bulges extend as bridges to be in contact with the core 2. This case is illustrated in Fig. 2, where a diametrical slice of the purging plug 1 along line A-A of Fig. 1 shows the surrounding layer 4, convex bulges 20 and the core 2.

[0054] It is well understood that in addition to securing the core vis a vis the surrounding layer, the bridges also maintain a distance between the core 2 and the surrounding layer 4 to preserve any interstice 7 that results from the foil 3 after it has been burned away.

[0055] The final purging plug 1 is typically able to deliver a flow rate comprised between 10 and several thousands $Nl.min^{-1}$ ("Nl" being an acronym meaning Normalized liter). The maximum value of the flow rate is mainly dependent on the thickness of the foil 3 and the gas permeability of the second material.

[0056] In some embodiments, the purging plugs of the present invention may also incorporate one or more wear indicators of the types generally known in the art. These can include for example embodiments wherein the core or ducts have a different shape at different heights within the plug, or wherein a separate wear indicating body is incorporated into the plug structure having different permeability, emissivity or other visible characteristics. In some instances, electronic wear indicators might also be used.

[0057] An example embodiment of a method for producing a purging plug will now be described.

[0058] This example relates to producing a purging plug comprising following features:

· a core made substantially of the first material having the first permeability;

· a surrounding layer around the core, made substantially of the second material having the second permeability, the second permeability being of higher value than the first permeability;

· a purging plug casing comprising the core and the surrounding layer.

[0059] Referring to Fig. 3, steps of a method for producing such a purging plug are represented in a flow chart. In a step 300 the purging plug casing is provided. A following step 301 is to provide a core of the purging plug, which is made substantially of the first material having the first permeability. The core is thus provided as a manufactured component ready for assembling and use. In step 302, the core is positioned inside the purging casing, whereby a second volume inside the purging plug casing is defined that is located between the core and a wall of the purging casing. The surrounding layer is obtained in step 303 by casting the second material having the second permeability into the second volume. Eventually in step 304, the purging plug casing and thus the freshly cast surrounding layer is fired at a temperature

sufficient to harden the second material, i.e., the surrounding layer.

[0060] The method illustrated in Fig. 3 may receive additional steps in a preferred embodiment for obtaining a purging plug with at least an interstice between the core and the surrounding layer. This preferred embodiment is illustrated in Fig. 4.

[0061] The at least one interstice is obtained by the use of a foil.

[0062] Before the step 302 of positioning the core inside the purging plug casing, the foil is provided in step 305, whereby the foil has a plurality of apertures distributed over a surface of the foil. The foil is then wrapped around the core in step 306.

[0063] After casting the second material, a step 307 of firing similar to step 304 of Fig. 3 allows not only to harden the surrounding layer, but also to burn the foil. This is achieved by firing at a sufficiently high temperature.

[0064] As a result, the purging plug obtains an interstice between the core and the surrounding layer where the foil was located.

[0065] By casting the second material in step 303, the second material penetrates the apertures of the foil to directly come in contact with the core. After the firing 307, the surrounding layer may be seen to have a plurality of convex bulges on its inner surface facing the core. These bulges create bridges between the surrounding layer and the core. An example of a purging plug obtained as a result of the method illustrated in Fig. 4 is shown in Fig. 2 previously described.

[0066] In a further preferred embodiment of either method from Fig. 3 or Fig. 4, the core may be provided with at least one channel therein, whereby the channel creates a gas passage duct for the blowing of gas through the purging plug. An example of a purging plug obtained with such a core comprising at least a channel through the method of Fig. 4 is shown in Fig. 5. The latter is similar to the illustration of Fig. 2 with the difference that the core comprises the channels 308.

[0067] A still further example of a method for producing a purging plug will now be described referring to Fig. 6.

[0068] This example relates to producing a purging plug comprising following features:

- a core made substantially of the first material having the first permeability;
- a surrounding layer around the core, made substantially of the second material having the second permeability, the second permeability being of higher value than the first permeability.

[0069] In a step 400 the surrounding layer is provided. The surrounding layer is thus provided as a manufactured component ready for assembling and use. The surrounding layer defines an inner volume that will receive the core.

[0070] In step 401, the first material is cast into the inner volume to obtain the core.

[0071] In step 402 the cast core is hardened by firing at a sufficient temperature.

[0072] The method illustrated in Fig. 6 may receive additional steps in a preferred embodiment for obtaining a purging plug with at least an interstice between the core and the surrounding layer. This preferred embodiment is illustrated in Fig. 7.

[0073] The at least one interstice is obtained by the use of a foil.

[0074] Before the step 401 of casting the first material to obtain the core, the foil is provided in step 403, whereby the foil has a plurality of apertures distributed over a surface of the foil. The foil is then wrapped on a wall of the inner volume, i.e., an inner wall of the surrounding layer, in step 404.

[0075] After casting the second material, a step 405 of firing similar to step 402 of Fig. 7 allows not only to harden the core, but also to burn the foil. This is achieved by firing at a sufficiently high temperature.

[0076] As a result, the purging plug obtains an interstice between the core and the surrounding layer where the foil was located.

[0077] By casting the first material in step 401, the first material penetrates the apertures of the foil to directly come in contact with the surrounding layer. After the firing 405, the core may be seen to have a plurality of convex projections on its surface facing the surrounding layer. These projections create bridges between the surrounding layer and the core.

[0078] In a further preferred embodiment of either method from Fig. 6 or Fig. 7, the core may be provided with at least one channel therein, whereby the channel creates a gas passage duct for the blowing of gas through the purging plug. The channel is obtained during the process of casting the first material in the inner volume.

[0079] A further example embodiment of a method for producing a purging plug will now be described in reference to Fig. 8.

[0080] This example relates to producing a purging plug comprising following features:

- a core made substantially of the first material having the first permeability;
- a surrounding layer around the core, made substantially of the second material having the second permeability, the second permeability being of higher value than the first permeability;
- a purging plug casing comprising the core and the surrounding layer;
- at least an interstice between the core and the surrounding layer;
- bridges between the core and the surrounding layer.

[0081] The interstice and the bridges will be obtained by the use of a foil.

[0082] In step 500, the foil is provided with apertures, which are distributed over a surface of the foil. The apertures may be distributed over the surface in many different patterns, e.g., in a grid pattern. The purging plug casing is then provided in step 501 . A hollow body is created in step 502 with the foil inside the empty casing such as to separate an inner volume of the casing into a first volume corresponding to the desired shape of the core, and a second volume corresponding to the surrounding layer and which is located between the foil and a wall of the casing. A castable first material having a first permeability is poured inside the first volume to obtain the core in step 503. Simultaneously to pouring the first material, in step 504 a castable second material having a second permeability is poured inside the second volume to obtain the surrounding layer. The second permeability is of higher value than the first permeability. Hence both the core and the surrounding layer are simultaneously cast in the casing until the whole desired shapes are achieved.

[0083] While the first material and the second material are being cast, either one of the materials may flow through the apertures. Hence some of the first material may flow from the first volume into the second volume and/or some of the second material may flow from the second volume into the first volume. However due to viscosity of both first and second materials, the flow in either direction between the first volume and the second volume will generally be marginal but sufficient to create bridges that contact the core and the surrounding layer through the apertures in order to anchor both core and surrounding layer between each other.

[0084] The foil which separates the core and the surrounding layer has a determined thickness corresponding to the desired interstices that will be formed after the foil is removed. The foil is removed by the effect of destruction caused by means of a high temperature. The high temperature is achieved in step 505 during a firing of the cast purging plug, whereby the temperature is raised to above 300°C, preferably even to 500°C. The firing of course also causes both the core and the surrounding layer to harden. The finished purging plug is obtained after the firing.

Claims

1. A purging plug (1) for blowing gas to be attached to an opening (41) of a molten metal treatment recipient, comprising:

   a core (2) having a shape extended along a longitudinal axis (40) from a bottom side (5) to a top side (6), wherein the core is substantially made of a first material, wherein the first material has a first permeability,

   a surrounding layer (4) arranged around the core in direction of the longitudinal axis from the bottom side to the top side, wherein the surrounding layer is substantially made of a second material, wherein the second material has a second permeability, the second permeability being of higher value than the first permeability,

   at least one gas passage duct (7) allowing a gas to flow through the gas passage duct from the bottom side to the top side, the gas passage duct being formed according to one of the following configurations:

   - the at least one gas passage duct is formed as an interstice (7) between the core and the surrounding layer,
   - the at least one gas passage duct is formed as a channel (308) in the core,
   - the at least one gas passage duct is formed as an interstice between the core and the surrounding layer and at least a further gas passage duct is formed as a channel in the core.

2. The purging plug of claim 1, further comprising:

   at least one convex projection formed on an external surface of the core facing the surrounding layer,

   a concave cavity formed on a internal surface of the surrounding layer facing the core, wherein the concave cavity fits the at least one convex projection, and the convex projection forms a bridge that secures the core from moving relative to the surrounding layer in direction of the longitudinal axis.

3. The purging plug of claim 1, further comprising:

   at least one convex projection formed on an external surface of the core facing the surrounding layer, wherein the convex projection extends as a bridge to be in contact with the surrounding layer.

4. The purging plug of claims 1, further comprising:

   at least one convex bulge (20) formed on an internal surface of the surrounding layer facing the core,

   a concave recess formed on an external surface of the core facing the surrounding layer, wherein the concave recess fits the at least one convex bulge, and the convex bulge forms a bridge that secures the core from moving relative to the surrounding layer in direction of the longitudinal axis.

5. The purging plug of claims 1, further comprising:

at least one convex bulge (20) formed on an internal surface of the surrounding layer facing the core, wherein the convex projection extends as a bridge to be in contact with the core.

6. The purging plug according to any one of claims 1 to 5, wherein
the shape of the core substantially corresponds to a solid cylinder extending along the longitudinal axis, and
the surrounding layer is dimensioned such that the purging plug takes an overall conical shape having its larger base diameter located at the bottom side and its smaller top diameter located at the top side.

7. The purging plug according to any one of claims 1 to 6, wherein
a thickness of the interstice measured in a direction perpendicular to the longitudinal axis is between 0,1 and 0,5 mm.

8. The purging plug according to any one of claims 1 to 7 further comprising a casing (8), whereby the casing encloses the core (2) and the surrounding layer (4).

9. The purging plug according to any one of claims 1 to 8, wherein
the first material is a dense refractory material that has an open porosity less than 30% measured after the EN1402 norm, and has a gas permeability by argon less than 10 Nanoperm, and
the second material is a porous refractory material that has an open porosity more than 30% measured after the EN1402 norm, and has a gas permeability by argon higher than 10 Nanoperm.

10. A metal treatment recipient having an opening with a purging plug according to any one of claims 1 to 9 inserted therein.

11. A method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient, comprising steps of providing a foil (500) with a plurality of apertures distributed over a surface of the foil,
providing a purging plug casing (501),
creating with the foil a hollow body (502) inside the purging plug casing such as to separate an inner volume of the purging plug casing into a first volume corresponding to a desired shape of a core, and a second volume being located between the foil and a wall of the purging plug casing,
casting a first material (503) having a first permeability into the first volume in order to obtain the core,
casting a second material (504) having a second permeability, the second permeability being of higher value than the first permeability, into the second volume in order to obtain a surrounding layer located around the core, the casting of the second material being done substantially simultaneously with the casting of the first material,
firing the purging plug casing (505) at a temperature sufficient to harden the core and the surrounding layer, and to burn the foil, whereby the foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

12. A method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient, comprising steps of providing a purging plug casing (300),
providing a core (301) of the purging plug, whereby the core is made substantially of a first material having a first permeability,
positioning the core (302) inside the purging plug casing, thereby defining a second volume inside the purging plug casing, the second volume being located between the core and a wall of the purging plug casing,
casting a second material (303) having a second permeability, the second permeability being of higher value than the first permeability, into the second volume in order to obtain a surrounding layer located around the core,
firing the purging plug casing (304) at a temperature sufficient to harden the surrounding layer.

13. The method of claim 12, further comprising
before the casting of the second material:

providing a foil (305) with a plurality of apertures distributed over a surface of the foil,
wrapping the foil (306) around the core,

and, after the casting of the second material:

firing the purging plug casing (307) at a temperature sufficient to harden the surrounding layer and to burn the foil,
whereby the foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

14. The method of claim 12 or 13, wherein the core comprises at least a channel, the channel creating a gas passage duct for the blowing of gas.

15. A method for producing a purging plug for blowing gas, to be attached to an opening of a molten metal treatment recipient, whereby the purging plug comprises a core and surrounding layer arranged around the core, the method comprising steps of

providing the surrounding layer (400), whereby the surrounding layer is made substantially of a second material having a second permeability, and the surrounding layer defines an inner volume to receive the core,
casting a first material (401) having a first permeability, the second permeability being of higher value than the first permeability, into the inner volume in order to obtain the core,
firing the purging plug casing (402) at a temperature sufficient to harden the core.

16. The method of claim 15, further comprising before the casting of the first material:

providing a foil (403) with a plurality of apertures distributed over a surface of the foil,
wrapping the foil on a wall of the inner volume,

and, after the casting of the first material:

firing the purging plug casing (405) at a temperature sufficient to harden the core and to burn the foil,
whereby the foil defines at least an interstice between the core and the surrounding layer, the interstice creating a gas passage duct.

17. The method of claim 15 or 16, wherein the core comprises at least a channel, the channel creating a gas passage duct for the blowing of gas.

18. The method according to any one of claims 11 to 17, wherein
the first material is a dense refractory material that has an open porosity less than 30% measured after the EN1402 norm, and has a gas permeability by argon less than 10 Nanoperm, and
the second material is a porous refractory material that has an open porosity more than 30% measured after the EN1402 norm, and has a gas permeability by argon higher than 10 Nanoperm.

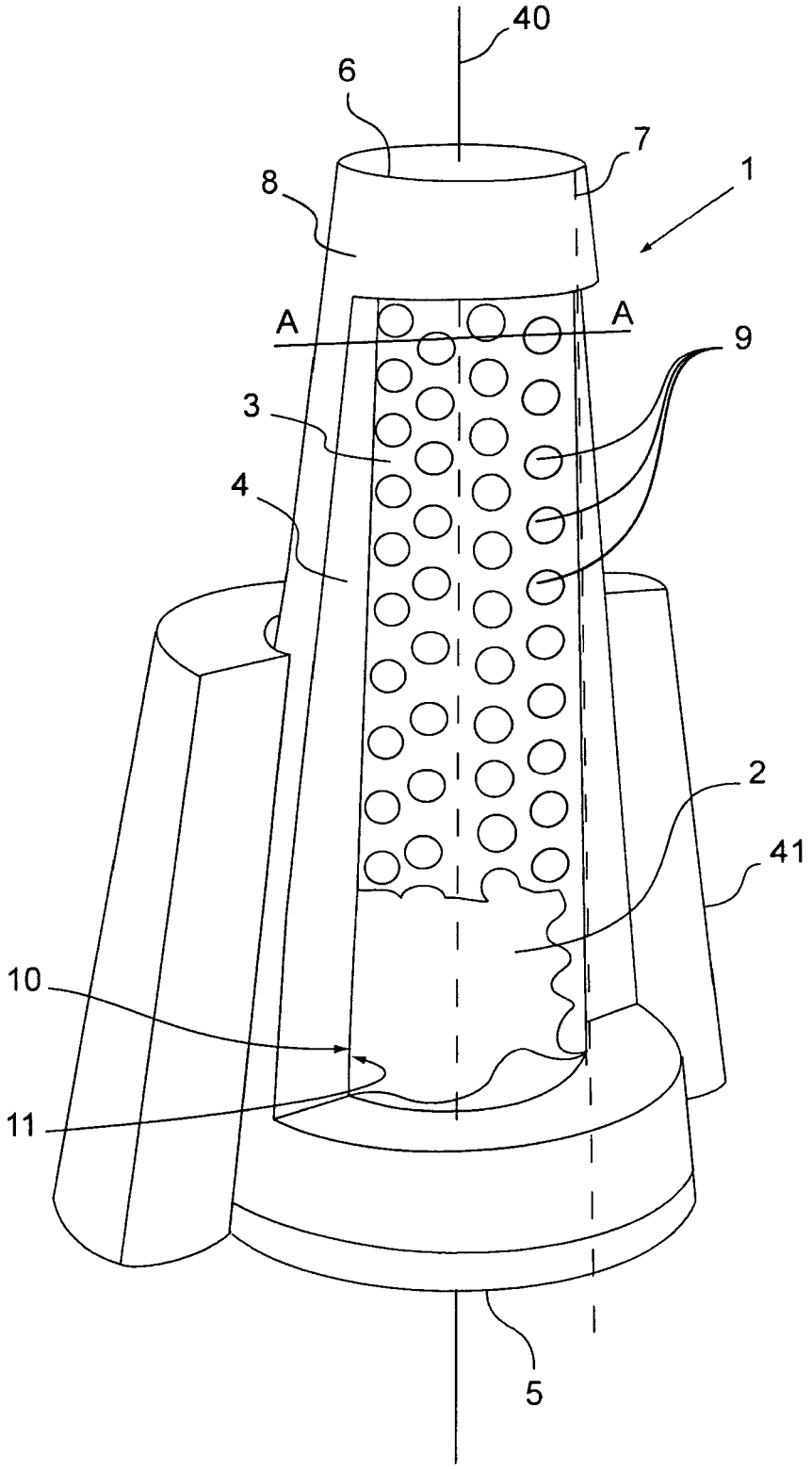

FIG.1

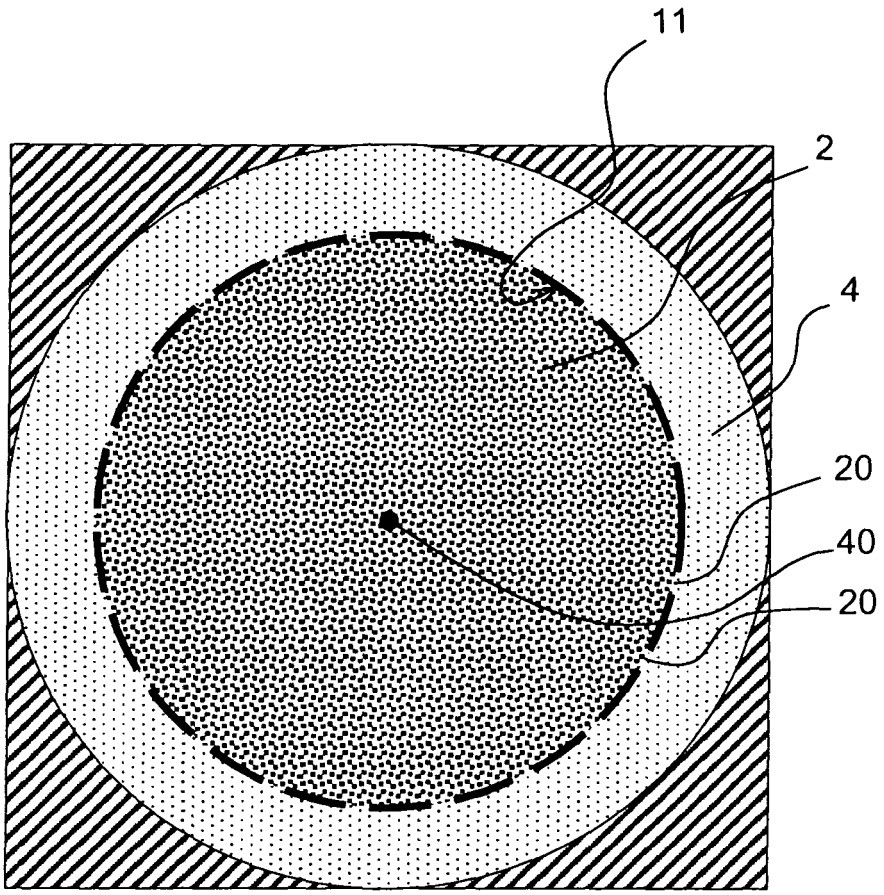

FIG.2

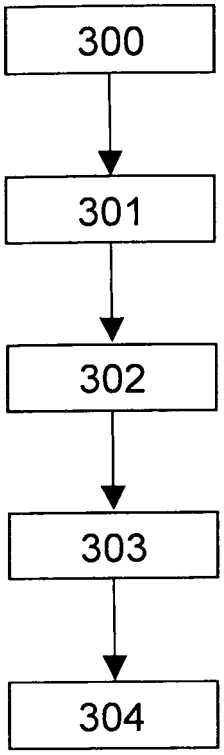

FIG.3

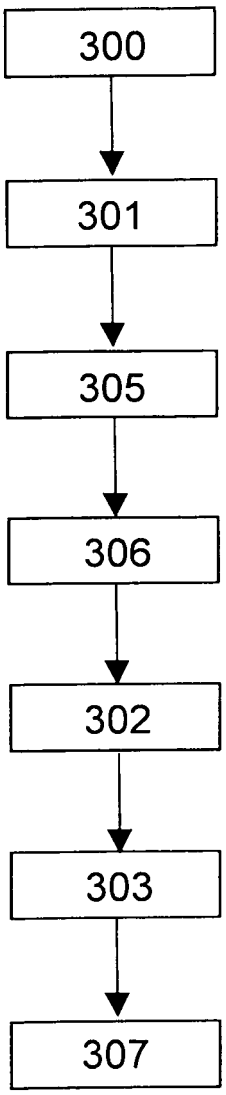

FIG.4

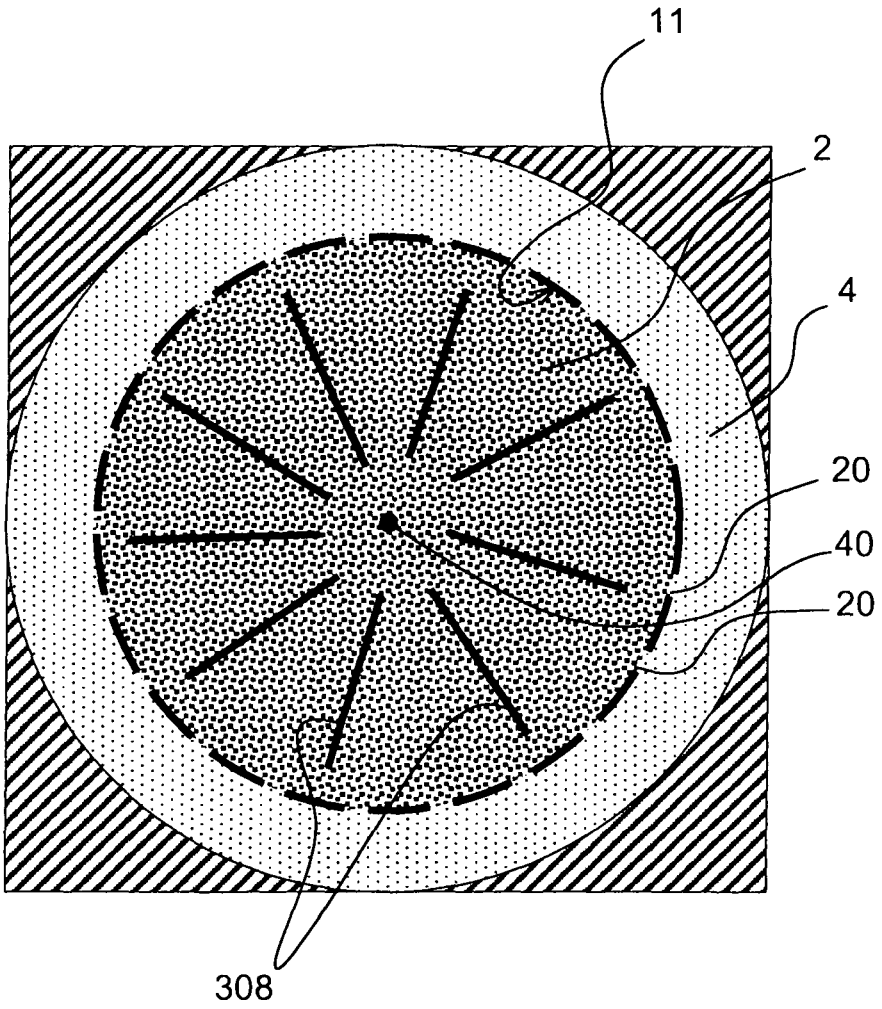

FIG.5

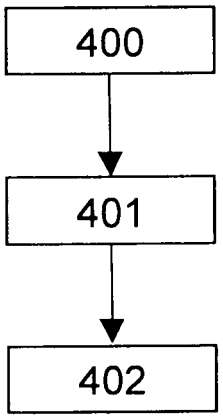

FIG.6

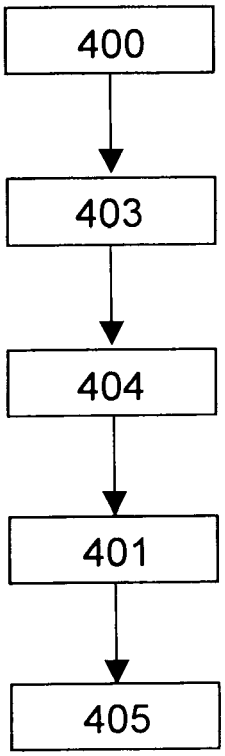

FIG.7

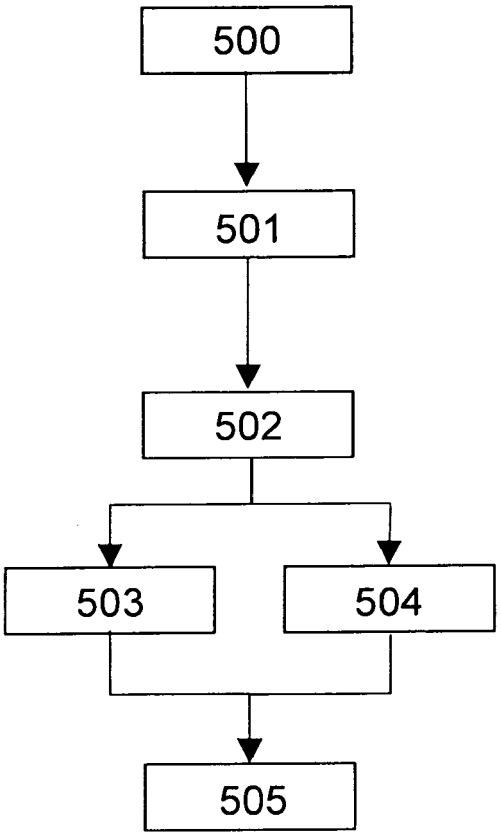

FIG.8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 5102

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 03/103877 A (VESUVIUS CRUCIBLE CO [US]; WILLOUGHBY CRAIG [GB]; MILLWARD CAVAN [GB];) 18 December 2003 (2003-12-18)	1,6,8,10	INV. B22D1/00 C21C5/48
X	* the whole document *	7,9,12, 15	
Y		2-5,11, 13,14, 16-18	
Y	EP 1 797 976 A (PA HA GE FEUERFESTE ERZEUGNISS [DE]) 20 June 2007 (2007-06-20) * figure 1 * * paragraph [0013] - paragraph [0021] *	2-5	
Y	DE 37 27 938 C1 (DIDIER WERKE AG) 8 September 1988 (1988-09-08) * figures 1-7 * * column 2, line 61 - column 3, line 30 *	2-5	
Y	US 2003/111778 A1 (ARAMAKI KEIZO [JP] ET AL) 19 June 2003 (2003-06-19) * figures 1,5 * * paragraph [0037] - paragraph [0041] *	11,13, 14,16-18	TECHNICAL FIELDS SEARCHED (IPC) B22D C21C F27D
Y	DE 195 04 941 A1 (KNOELLINGER HORST [DE]) 22 August 1996 (1996-08-22) * the whole document *	11,13, 14,16-18	
Y	DE 198 46 524 A1 (KNOELLINGER KERAMISCHE ERZEUGN [DE]) 13 April 2000 (2000-04-13) * the whole document *	11,13, 14,16-18	
Y	EP 0 490 062 A (DIDIER WERKE AG [DE]) 17 June 1992 (1992-06-17) * column 2, line 18 - column 3, line 29 *	11,13, 14,16-18	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 September 2008	Scheid, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

4

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 15 5102

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17-09-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03103877 A	18-12-2003	AT 313400 T	15-01-2006
		AU 2003249790 A1	22-12-2003
		BR 0311420 A	15-03-2005
		CA 2487879 A1	18-12-2003
		CN 1658987 A	24-08-2005
		DE 60302894 T2	20-07-2006
		ES 2253701 T3	01-06-2006
		MX PA04012192 A	25-02-2005
		RU 2314176 C2	10-01-2008
		US 2005218568 A1	06-10-2005
EP 1797976 A	20-06-2007	BR PI0605215 A	09-10-2007
		CN 101012488 A	08-08-2007
		DE 102005060432 A1	21-06-2007
DE 3727938 C1	08-09-1988	BR 8804193 A	14-03-1989
		CA 1327267 C	01-03-1994
		CN 1031832 A	22-03-1989
		EP 0304551 A1	01-03-1989
		ES 2029697 T3	01-09-1992
		GR 3004183 T3	31-03-1993
		JP 1076977 A	23-03-1989
		US 4905971 A	06-03-1990
		ZA 8806001 A	26-04-1989
US 2003111778 A1	19-06-2003	NONE	
DE 19504941 A1	22-08-1996	AT 169848 T	15-09-1998
		BR 9510450 A	19-05-1998
		CA 2212715 A1	22-08-1996
		WO 9625259 A1	22-08-1996
		EP 0809554 A1	03-12-1997
		ES 2121401 T3	16-11-1998
		RU 2127650 C1	20-03-1999
		US 5855843 A	05-01-1999
DE 19846524 A1	13-04-2000	NONE	
EP 0490062 A	17-06-1992	AT 182182 T	15-07-1999
		CA 2057167 A1	09-06-1992
		DE 4039232 A1	11-06-1992
		JP 5004881 A	14-01-1993
		US 5279993 A	18-01-1994

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82