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(54) **A LANCE TUBE**

LANZENROHR

TUBE DE LANCE

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(56) References cited:

EP-A1- 1 018 563 WO-A1-2006/068606
DE-A1- 3 122 178 JP-A- H09 257 167

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Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a lance tube according to the preamble of claim 1. In particular, but not exclusively, the disclosure relates to a lance tube intended for use in a lime kiln furnace. The lance tube may also be intended for use in e.g. a pulverized coal injection lance for blast furnaces.

BACKGROUND AND PRIOR ART

10 **[0002]** In the production of quicklime (calcium oxide) from limestone (calcium carbonate), a lime kiln is used for the calcination process. The most commonly used lime kiln is the parallel flow regenerative (PFR) shaft kiln, consisting of two vertical shafts and a connecting crossover channel. While limestone is calcined in a combustion zone in one of the shafts, the other shaft preheats the limestone. The hot combustion gases are transferred from the calcining shaft through
 15 the crossover channel to the non-calcining shaft, where they preheat the limestone in an upper area of the shaft. The flow direction of the gases is reversed at regular intervals. This allows regenerative preheating of the limestone to take place and this type of lime kiln is therefore energy efficient. Fuel is delivered into the calcining shaft via lances protruding into the combustion zone. Since the calcination process requires high temperatures of around 1000°C, the lance has to be heat resistant.

20 **[0003]** The lance comprises a lance tube, which is subjected to severe high-temperature corrosion conditions due to the high temperature, corrosive elements in the fuel and erosion from the limestone. The main corrosion mechanisms in lime kilns are oxidation, sulphidation and erosion-corrosion. The most severe corrosion commonly occurs about 50-100 cm from the lower end of the lance tube, delivering the fuel into the combustion zone. Corrosion may in this area lead to that the lance breaks and is thereby shortened. Since the shortening alters the kiln combustion parameters and
 25 reduces its efficiency, broken lances need to be replaced. An example of such lances can be found in EP1018563A1.

[0004] Common materials used for the lance tube include chromium oxide forming steel alloys such as the ferritic stainless steel alloy ASTM 446, and the austenitic stainless steel alloys UNS S35315, UNS S30815, ASTM 310 and ASTM 316. The life time of a lance tube is typically about six months to two years.

30 **[0005]** Attempts have previously been made to use alumina forming alloys, such as e.g. iron chromium aluminium (FeCrAl), in lance tube applications. Such alloys form a protective alumina scale and are known to be very corrosion resistant at high temperatures. However, in addition to being relatively expensive, FeCrAl alloys are brittle at low temperature and are also difficult to weld.

SUMMARY

35 **[0006]** In view of the above-mentioned problems, it is desirable to provide a lance tube which is in at least some aspect improved with respect to known lance tubes. In particular, it is desirable to provide a lance tube for use in lime kilns or for use in a lime furnace burner, in blast furnace coal powder injection and in sootblower elements, that has an improved life time in comparison with known lance tubes.

40 **[0007]** This is achieved by the initially defined lance tube of the appended claims, which comprises:

- a double-layered end portion having an annular outer layer of a high temperature corrosion resistant first alloy and an annular inner layer of a second alloy, wherein the annular inner layer and the annular outer layer are mechanically interlocked, and wherein a metallic bond has been formed between the annular inner layer and the annular outer
 45 layer by means of hot extrusion and
- a mono-layered main portion of the second alloy, wherein the annular inner layer and the annular outer layer are mechanically interlocked by means of a helically extending thread formed in an interface between the inner layer and the outer layer.

50 **[0008]** At the double-layered end portion, intended to form the lower end of the lance tube, the annular outer layer of a high temperature corrosion resistant alloy provides increased corrosion resistance at the crucial portion of the lance tube. In a lime kiln, this portion will be located at the bottom of the kiln, where the highest temperatures will be experienced. The improved corrosion resistance is achieved without having to compromise the mechanical properties and high temperature wear resistance of the lance tube. The metallic bond between the annular inner and outer layers ensures that
 55 there is no air gap between the layers which may lead to reduced thermal conductivity. Thus, a good thermal conductivity of the lance tube is achieved even though two different alloys (alloys having different compositions) are used. The metallic bond between the layers should be formed in a main portion of an interface between the annular inner and outer layers, but there may be smaller portions of the interface in which no metallic bond is present. The metallic bond is formed by

means of hot extrusion.

[0009] The mechanical interlocking is provided before hot extrusion to achieve the metallic bond. The mechanical interlock will form a seal preventing oxygen from entering between the layers during the hot working process, and it will additionally keep the annular inner and outer layers together during hot working, i.e. prevent them from sliding. The mechanical interlock thereby makes it possible to achieve the proposed lance tube without having to weld a base component and an outer component together before hot working. Thus, the lance tube can be made from two alloys that are normally difficult to join by means of welding. Furthermore, the combination of a mechanical interlock and a metallic bond between the layers is beneficial for the ability of the lance tube to withstand high forces.

[0010] The annular inner layer and the annular outer layer are mechanically interlocked by means of a helically extending thread formed in an interface between the annular inner layer and the annular outer layer. The helically extending thread forms an efficient interlock and also increases the interfacial area, which will thereby contribute to an improved distribution of forces applied to the lance tube in comparison with a lance tube without such a helically extending thread. Thus, the lance tube will be able to withstand higher load in the interface between the layers.

[0011] According to one embodiment, the mono-layered main portion extends along a major part of the lance tube as measured along the longitudinal axis. The mono-layered portion may extend along more than half of the length of the lance tube, or along more than 75 % of the length of the lance tube. The double-layered portion is thus relatively short and only covers the crucial part of the lance tube, where additional high temperature corrosion resistance is needed. If an expensive first alloy is used for the outer layer, this reduces the total cost of the lance tube without compromising its life time. The double-layered portion may typically extend along at least 70-150 cm of the lance tube, intended to form the lower part of the tube from which fuel is delivered. The length of the lance tube as measured in the axial direction may be several meters.

[0012] According to one embodiment, the second alloy is selected from a stainless steel alloy or a carbon steel. Stainless steel alloys and carbon steels that have desired mechanical strength and high temperature wear resistance are suitable choices for the main portion and the inner layer of the lance tube. An example of a suitable carbon steel is a carbon steel according to standard DIN 17135A, this carbon steel comprises from 0.1 to 0.3 C and 0.1 to 2.0 Mn and balance Fe and unavoidable impurities.

[0013] According to one embodiment, the second alloy is selected from a ferritic stainless steel alloy or an austenitic stainless steel alloy. Suitable alloys but not limited to are e.g. the ferritic stainless steel alloy ASTM 446-1, and the austenitic stainless steel alloys UNS S35315, UNS S30815, UNS N08810/N08811, ASTM 310, and ASTM 316/316H. These alloys will provide both the desired mechanical properties and sufficient high temperature corrosion resistance and wear resistance for the main portion of the lance tube and are suitable choices in e.g. lime kiln applications.

[0014] According to one embodiment, the first alloy is an alumina forming alloy. Alumina forming alloys form a protective alumina scale on the outer surface of the annular outer layer which will provide excellent high temperature corrosion resistance. Suitable alumina forming alloys include iron chromium aluminium (FeCrAl) alloys as well as other alumina forming alloys.

[0015] According to one embodiment, the alumina forming alloy is an iron chromium aluminium alloy. FeCrAl alloys, such as FeCrAl alloys sold under the trademark Kanthal® APM and Kanthal® APMT, have suitable high temperature corrosion resistance for use as the outer layer. In order to achieve improved creep strength, it is possible to use an oxide dispersion-strengthened alloy produced by means of powder metallurgy. However, the alloy can also be conventionally manufactured using melting and casting techniques.

[0016] According to one embodiment, the first alloy comprises:

9-25 wt. % Cr,
2.5-8 wt. % Al,

the balance being Fe and normally occurring impurities, and optionally other intentionally added alloying elements. In one embodiment, the first alloy comprises 20-25 wt. % Cr and 5-7 wt. % Al, the balance being Fe and normally occurring impurities. In another embodiment, the first alloy comprises 20-25 wt. % Cr, 5-7 wt. % Al and 1 to 4 Mo the balance being Fe and normally occurring impurities.

[0017] According to one embodiment, the first alloy is a stainless steel alloy comprising cerium, such as a chromium oxide forming austenitic stainless steel alloy comprising cerium. The addition of cerium stabilises the chromium oxide at high temperatures and thereby improves the high temperature corrosion properties as well as provides a good structural stability at high temperatures. Suitable alloys are e.g. UNS S30815 and UNS S35315, which alloys comprise C 0.04 to 0.10, Mn 1 to 2, Cr 20 to 26, Ni 10 to 12 or 34 to 36, N 0.12 to 0.20, Ce 0.03 to 0.08, balance Fe and unavoidable impurities.

[0018] According to one embodiment, the annular outer layer has a thickness within the interval 5-50 % of a total wall thickness. The thickness should be sufficient to achieve the desired high temperature corrosion resistance without risking that the annular outer layer cracks or is otherwise discontinued.

[0019] According to one embodiment, the annular outer layer has a thickness within the interval 10-40 % of a total

wall thickness, such as to ensure sufficient corrosion resistance at a reasonable cost.

[0020] According to one embodiment, the lance tube has a total wall thickness within the interval 3-20 mm. The wall thickness depends on e.g. the dimension of the lance tube. For example, for outer diameters of approximately 60 mm, 50 mm, 40 mm, 30 mm and 12 mm, wall thicknesses of approximately 10 mm, 9 mm, 6 mm and 3 mm, respectively, may be suitable.

[0021] According to one embodiment, an outer diameter of the lance tube as measured at each of the mono-layered main portion and the double-layered end portion is identical or essentially identical.

[0022] According to one embodiment, an inner diameter of the lance tube as measured at each of the mono-layered main portion and the double-layered end portion is identical or essentially identical. This is beneficial for the flow characteristics of the lance tube.

[0023] The disclosure also relates to use of the proposed lance tube as a lance tube in a lime kiln. The proposed lance tube may also be used in other applications requiring high temperature corrosion resistance in combination with mechanical strength, such as in a lime furnace burner, in blast furnace coal powder injection and in sootblower elements.

[0024] Other advantageous features as well as advantages of the proposed lance tube and method of manufacturing will appear from the following description.

DEFINITIONS

[0025] A lance tube is herein to be understood as a tube having a relatively small diameter compared to its length, which is intended for use in lime kilns or for use in a lime furnace burner, in blast furnace coal powder injection and in sootblower elements. The lance tube is used for fuel transfer from a first end of the lance tube to a second end of the lance tube, wherein the first end is connected to a fuel supply system and the second end is open. The lance tube is not pressurized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Embodiments of the proposed lance tube and a method of manufacturing, not to be interpreted as limiting, will in the following be described with reference to the appended drawings, in which

- Fig. 1 schematically shows a perspective view of a lance tube according to an embodiment,
- Fig. 2 schematically shows a lance tube according to another embodiment in cross section,
- Fig. 3a-c schematically shows a base component and an outer component for manufacturing a lance tube,
- Fig. 4 schematically shows a longitudinal cross section of parts of a base component and an inner component for manufacturing a lance tube,
- Fig. 5 schematically shows a longitudinal cross section of parts of a work piece for manufacturing a lance tube, and
- Fig. 6 shows a longitudinal cross sectional picture of an interface within a lance tube.

DETAILED DESCRIPTION

[0027] Fig. 1 schematically, and not to scale, shows a lance tube 1 according to an embodiment of the present disclosure. The lance tube has a relatively short double-layered end portion 2 and a mono-layered main portion 3. The double-layered end portion 2 has an annular outer layer 4 of a first alloy and an annular inner layer 5 of a second alloy. The mono-layered main portion 3 is entirely formed of the second alloy that the inner layer 5 of the double-layered end portion 2 is formed of.

[0028] Fig. 2 schematically shows a straight lance tube 1 in a cross section taken along a longitudinal axis A of the lance tube. As can be seen in the magnification of the marked area, a helically extending thread 6 extends in an interface between the annular outer layer 4 and the annular inner layer 5. The helically extending thread 6 serves to mechanically interlock the two layers 4, 5. However, the layers 4, 5 are also bound by a metallic bond formed in the interface by means of hot working, e.g. hot extrusion.

[0029] A lance tube according to the present disclosure may be manufactured from components shown in figs. 3a-c. The components include a base component 301 of the second alloy, which is to form the inner layer 5 of the lance tube 1, and an outer component 401 of the first alloy, which is to form the outer layer 4 of the lance tube 1.

[0030] The base component 301 is a tube of circular cross section, having a central through-hole extending along a longitudinal axis A. An externally threaded section 302 is provided, having a helical thread 306 (see fig. 3b) formed in an outer peripheral surface of an end portion of the base component 301. The shown base component 301 has a non-threaded section 303 adjacent the threaded section 302. An inner diameter d of the base component is constant or essentially constant along the longitudinal axis, but an outer diameter D1 of the non-threaded section 303 is larger than an outer diameter D2 of the threaded section 302.

[0031] The outer component 401 is also a tube of circular cross section, having a central through-hole extending along the longitudinal axis A. In the shown embodiment, the outer component 401 has a length in the longitudinal direction corresponding to a length of the threaded section 302 of the base component 301. The outer component 401 has an internally threaded section 402, in the shown embodiment extending along the entire length of the outer component 401. In other words, a helical thread 406 (see fig. 3c) is formed in an inner peripheral surface of the outer component 401. The outer component 401 is thereby configured for threaded engagement with the externally threaded section 302 of the base component 301. An outer diameter D3 of the outer component 401 is equal to or essentially equal to the outer diameter D1 of the non-threaded section 303 of the base component 301, while an inner diameter d2 of the outer component 401 matches the outer diameter D2 of the threaded section 302 of the base component 301.

[0032] A tubular work piece is formed by mounting the outer component 401 around the base component 301 such that the internally threaded section 402 of the outer component 401 is in engagement with the externally threaded section 302 of the base component 301, i.e. by threading the outer component 401 onto the threaded end portion of the base component 301. A mechanical interlock is thereby formed between the threaded sections 302, 402.

[0033] The work piece is thereafter hot worked, e.g. by means of hot extrusion. During hot working, such as hot extrusion, a metallic bond is formed between the threaded sections 302, 402 while the mechanical interlock is maintained. An outer diameter of the work piece is also reduced and the length is increased. Straightening and/or pickling may be carried out before the resulting lance tube 1 is cut into its final length and, if needed, formed to a desired shape.

[0034] The components 301, 401 shown in fig. 3a are adapted for hot extrusion by pushing the work piece through an extrusion die with a leading end first, wherein the leading end is the end at which the outer component 401 is mounted. A transition surface 308 between the externally threaded section 302 of the base component 301 and the non-threaded section 303 is smooth, without sharp edges. The transition surface 308 is shown in more detail in fig. 3b, showing a magnification of the encircled area B from fig. 3a. The transition surface is in cross section shaped as an inverted S with a concave portion 304 closest to the threaded section 302, and a convex portion 305 closest to the non-threaded section 303. The outer component 401 has an end surface 408 with a corresponding S-shape with a convex portion 404 close to the internal thread 406, and a concave portion 405 close to an outer peripheral surface 407 of the outer component 401 as shown in fig. 3c showing a magnification of the encircled area C from fig. 3a. The concave portion 405 of the end surface 408 will thereby overlap with the convex portion 305 of the transition surface 308, which prevents separation and penetration of oxygen during the extrusion process.

[0035] Another option is to let the leading end in the extrusion process be the end on which no outer component is mounted. In this case, shown in fig. 4, the base component 301 is formed with a C-shaped concave transition surface 308, such that it floats over a rounded annular end surface 408 of the outer component 401 during extrusion and forms a seal. An outer peripheral surface 307 of the base component 301 thus overlaps the outer peripheral surface 407 of the outer component 401 when the components 301, 401 are mounted to form the work piece.

[0036] Fig. 5 shows a cross sectional view of parts of a work piece 501 adapted for hot extrusion by pushing the work piece 501 through an extrusion die with a leading end 502 first, wherein the leading end 502 is the end at which the outer component 401 is mounted. The ends on which the outer components 401 are mounted have been machined to form rounded end surfaces 503. The design of the transition surfaces 308, 408 of the base component 301 and the outer component 401, respectively, differs in this embodiment somewhat from the design shown in figs. 3a-c. The transition surface 308 of the base component 301 includes, as seen in the cross section, a first straight portion 309 perpendicular to the longitudinal axis A, and a second straight portion 310 which is inclined at an angle α of 30° with respect to the longitudinal axis A. A curved surface connects the two straight portions 309, 310. The angle α may of course be varied.

[0037] The transition surface 408 of the outer component 401 is formed to engage and overlap with the transition surface 308, such that a seal is formed. Of a total wall thickness t of the outer component, the first straight portion 309 extends over a thickness h .

Example

[0038] In a production trial, ten lance tubes according to the embodiment shown in fig. 1 were manufactured. Ten outer components of a first alloy and ten base components of a second alloy were formed. The first alloy was in this case an iron chromium aluminium (FeCrAl) alloy known under the trademark Kanthal® APM. The composition of the first alloy as measured in percent by weight (wt.%) is disclosed in Table I.

Table I

C	Si	Mn	Al	Cr	Fe
≤0.08	≤0.07	0.7	6	22	Balance

[0039] The second alloy was a ferritic stainless steel according to ASTM 446-1 having a composition in wt.% as disclosed in Table II.

Table II

C	Si	Mn	P	S	Cr	N	Fe
≤0.20	0.5	0.8	≤0.030	≤0.015	26.5	0.2	balance

[0040] Each base component had a total length of 400 mm, an outer diameter D1 of 164 mm and an inner diameter d of 41 mm. An externally threaded section having a length of 95 mm and an outer diameter D2 of 154 mm was formed by cutting machining. The outer components each had a length of 95 mm and an inner diameter d2 of 154 mm and were provided with an internal helical thread. The components had the transitional design shown in fig. 5. A wall thickness t of the outer component was 5 mm and the thickness h was 1.8 mm. The helical thread had a pitch of 2 mm.

[0041] The components were degreased using ethanol. The outer components 401 were thereafter threaded onto the base components 301 to form work pieces such as shown fig. 5.

[0042] The work pieces were thereafter heated to 900°C and hot extruded at temperatures shown in table III. The work pieces were extruded with the end on which the outer component was mounted as the leading end.

Table III

Work piece	Extrusion temp. (°C)
S1	1120
S2	1120
S3	1120
S4	1120
S5	1120
S6	1090
S7	1090
S8	1070
S9	1070
S10	1050

[0043] After hot extrusion, the formed tubes were straightened and blasted using steel sand.

[0044] The lengths of the double-layered portions of the manufactured lance tubes were found to be between 70 cm and 120 cm. A thickness of the outer layer was measured in test samples using optical and electron microscopy and was found to be between 600-900 μm.

[0045] Using energy-dispersive X-ray spectroscopy, it was also investigated whether a protective aluminium oxide scale had been formed on the outer layer of the double-layered portion during the heat treatment and whether a metallic bond had been formed between the inner and outer layers. It was found that an aluminium oxide scale had been formed on the surface of the outer layer and that aluminium nitride precipitates had formed in the outer layer, indicating nitrogen diffusion from the inner layer of the second alloy ASTM 446-1 into the outer layer of the first alloy sold under the trademark Kanthal® APM, which in turn indicates formation of a metallic bond.

[0046] Fig. 6 shows a cross sectional picture of a part of the interface between the inner layer 5 and the outer layer 4 of the double-layered portion of a manufactured lance tube according to an embodiment. The picture is taken at a foremost portion of the lance tube, corresponding to the leading end of the work piece. A helically extending thread 6 is clearly seen. Thus, while a metallic bond has been formed in the interface, the inner and outer layers are still also mechanically bound together.

[0047] The dimensions of the components used may of course be varied depending on the desired dimensions of the final lance tube, as well as the alloys used and the parameters used during hot working, e.g. hot extrusion. Various other processing steps may also be included, such as pre-heating and cold pilgering. The design of the base component and the outer component can be varied depending on the requirements on the final lance tube.

[0048] The proposed lance tube may be shaped to suit the requirements of the lime kiln or other application in which it is to be used. The design of the lance tube may be varied, for example by letting all or part of the double-layered portion

have an outer diameter which is different than, for example smaller than, the outer diameter of the main portion. The double-layered end portion of the lance tube may also include a portion entirely made of the first alloy that the outer layer is made of, so that the high temperature corrosion resistant first alloy covers the end of the lance tube.

[0049] The proposed lance tube is not limited to the embodiments described above, but many possibilities to modifications thereof would be apparent to a person with skill in the art without departing from the scope of the appended claims.

Claims

1. A lance tube (1) having a central through-hole extending along a longitudinal axis (A),
characterised in
that the lance tube (1) comprises:
 - a double-layered end portion (2) having an annular outer layer (4) of a high temperature corrosion resistant first alloy and an annular inner layer (5) of a second alloy, wherein the annular inner layer (5) and the annular outer layer (4) are mechanically interlocked, and wherein a metallic bond has been formed between the annular inner layer (5) and the annular outer layer (4) by means of hot extrusion, and
 - a mono-layered main portion (3) of the second alloy and
 - wherein the annular inner layer (5) and the annular outer layer (4) are mechanically interlocked by means of a helically extending thread (6) formed in an interface between the inner layer (5) and the outer layer (4).
2. The lance tube according to claim 1, wherein the mono-layered main portion (3) extends along a major part of the lance tube (1) as measured along the longitudinal axis (A).
3. The lance tube according to any one of claims 1-2, wherein the second alloy is selected from a stainless steel alloy or a carbon steel.
4. The lance tube according to any one of the preceding claims, wherein the second alloy is selected from a ferritic stainless steel alloy or an austenitic stainless steel alloy.
5. The lance tube according to any one of the preceding claims, wherein the first alloy is an alumina forming alloy.
6. The lance tube according to claim 5, wherein the alumina forming alloy is an iron chromium aluminium alloy.
7. The lance tube according to any one of the preceding claims, wherein the first alloy comprises:

9-25 wt. % Cr,
2.5-8 wt. % Al,

the balance being Fe and normally occurring impurities, and optionally other intentionally added alloying elements.
8. The lance tube according to any one of the preceding claims, wherein the annular outer layer (4) has a thickness within the interval 5-50 % of a total wall thickness.
9. The lance tube according to any one of the preceding claims, wherein the annular outer layer (4) has a thickness within the interval 10-40 % of a total wall thickness.
10. The lance tube according to any one of the preceding claims, wherein the lance tube (1) has a total wall thickness within the interval 3-20 mm.
11. The lance tube according to any one of the preceding claims, wherein an outer diameter of the lance tube (1) as measured at each of the mono-layered main portion (3) and the double-layered end portion (2) is identical or essentially identical.
12. The lance tube according to any one of the preceding claims, wherein an inner diameter of the lance tube as measured at each of the mono-layered main portion and the double-layered end portion is identical or essentially identical.

13. Use of a lance tube (1) according to any one of the preceding claims as a lance tube in a lime kiln, in a lime furnace burner, in blast furnace coal powder injection and in sootblower elements.

Patentansprüche

1. Lanzenrohr (1), das ein zentrales Durchgangsloch aufweist, das sich entlang einer Längsachse (A) erstreckt,

dadurch gekennzeichnet, dass

das Lanzenrohr (1) Folgendes umfasst:

- einen zweischichtigen Endabschnitt (2), der eine ringförmige Außenschicht (4) aus einer hochtemperaturkorrosionsfesten ersten Legierung und eine ringförmige Innenschicht (5) aus einer zweiten Legierung aufweist, wobei die ringförmige Innenschicht (5) und die ringförmige Außenschicht (4) mechanisch verblockt sind, und wobei eine metallische Bindung zwischen der ringförmigen Innenschicht (5) und der ringförmigen Außenschicht (4) mittels Warmstrangpressen gebildet wurde, und

einen einschichtigen Hauptabschnitt (3) aus der zweiten Legierung, und wobei die ringförmige Innenschicht (5) und die ringförmige Außenschicht (4) mittels eines sich schraubenförmig erstreckenden Gewindes (6), das an einer Grenzfläche zwischen der Innenschicht (5) und der Außenschicht (4) gebildet ist, mechanisch verblockt sind.

2. Lanzenrohr nach Anspruch 1, wobei sich der einschichtige Hauptabschnitt (3) entlang eines Großteils des Lanzenrohrs (1), gemessen entlang der Längsachse (A), erstreckt.

3. Lanzenrohr nach einem der Ansprüche 1-2, wobei die zweite Legierung ausgewählt ist aus einer Edelstahllegierung oder einem Kohlenstoffstahl.

4. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei die zweite Legierung ausgewählt ist aus einer ferritischen Edelstahllegierung oder einer austenitischen Edelstahllegierung.

5. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei die erste Legierung eine Aluminiumoxid bildende Legierung ist.

6. Lanzenrohr nach Anspruch 5, wobei die Aluminiumoxid bildende Legierung eine Eisen-Chrom-Aluminium Legierung ist.

7. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei die erste Legierung Folgendes umfasst:

9 - 25 Gew.-% Cr,

7.5 - 8 Gew.-% Al,

wobei die Differenz Fe und normal auftretende Unreinheiten und optional andere vorsätzlich beigegebene Legierungselemente sind.

8. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei die ringförmige Außenschicht (4) eine Dicke innerhalb des Intervalls von 5 - 50 % der Gesamtwanddicke aufweist.

9. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei die ringförmige Außenschicht (4) eine Dicke innerhalb des Intervalls von 10 - 40 % der Gesamtwanddicke aufweist.

10. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei das Lanzenrohr (1) eine Gesamtwanddicke innerhalb des Intervalls von 3-20 mm aufweist.

11. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei ein Außendurchmesser des Lanzenrohrs (1), gemessen jeweils am einschichtigen Hauptabschnitt (3) und am zweischichtigen Endabschnitt (2), identisch oder im Wesentlichen identisch ist.

12. Lanzenrohr nach einem der vorstehenden Ansprüche, wobei ein Innendurchmesser des Lanzenrohrs, gemessen

jeweils am einschichtigen Hauptabschnitt und am zweischichtigen Endabschnitt, identisch oder im Wesentlichen identisch ist.

13. Verwendung eines Lanzenrohrs (1) nach einem der vorstehenden Ansprüche als Lanzenrohr in einem Kalkofen, in einem Kalkofenbrenner, bei Hochofen-Kohlepulverspritzguss und bei Rußbläselementen.

Revendications

1. Tube de lance (1) présentant un trou traversant central s'étendant le long d'un axe longitudinal (A),

caractérisé en ce que

le tube de lance (1) comprend :

- une portion d'extrémité bicouche (2) présentant une couche externe (4) annulaire d'un premier alliage résistant à la corrosion à haute température et une couche interne (5) annulaire d'un second alliage, dans lequel la couche interne (5) annulaire et la couche externe (4) annulaire sont liées l'une à l'autre mécaniquement, et dans lequel une liaison métallique a été formée entre la couche interne (5) annulaire et la couche externe (4) annulaire au moyen d'une extrusion à chaud, et

une portion principale monocouche (3) du second alliage et dans lequel la couche interne (5) annulaire et la couche externe (4) annulaire sont liées l'une à l'autre mécaniquement au moyen d'un filetage (6) s'étendant de manière hélicoïdale formé dans une interface entre la couche interne (5) et la couche externe (4).

2. Tube de lance selon la revendication 1, dans lequel la portion principale monocouche (3) s'étend le long d'une partie majeure du tube de lance (1) telle que mesurée le long de l'axe longitudinal (A).

3. Tube de lance selon l'une quelconque des revendications 1 et 2, dans lequel le second alliage est choisi parmi un alliage d'acier inoxydable ou un acier au carbone.

4. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel le second alliage est choisi parmi un alliage d'acier inoxydable ferritique ou un alliage d'acier inoxydable austénitique.

5. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel le premier alliage est un alliage formant de l'alumine.

6. Tube de lance selon la revendication 5, dans lequel l'alliage formant de l'alumine est un alliage de fer, de chrome et d'aluminium.

7. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel le premier alliage comprend :

9 à 25 % en poids de Cr,

7,5 à 8 % en poids d'Al,

le reste étant du Fe et des impuretés naturelles, et optionnellement d'autres éléments d'alliage ajoutés de manière intentionnelle.

8. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel la couche externe (4) annulaire présente une épaisseur à l'intérieur de l'intervalle de 5 à 50 % d'une épaisseur totale de paroi.

9. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel la couche externe (4) annulaire présente une épaisseur à l'intérieur de l'intervalle de 10 à 40 % d'une épaisseur totale de paroi.

10. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel le tube de lance (1) présente une épaisseur totale de paroi à l'intérieur de l'intervalle de 3 à 20 mm.

11. Tube de lance selon l'une quelconque des revendications précédentes, dans lequel un diamètre externe du tube de lance (1) tel que mesuré au niveau de chacune de la portion principale monocouche (3) et de la portion d'extrémité

bicouche (2) est identique ou essentiellement identique.

- 5 **12.** Tube de lance selon l'une quelconque des revendications précédentes, dans lequel un diamètre interne du tube de lance tel que mesuré au niveau de chacune de la portion principale monocouche et de la portion d'extrémité bicouche est identique ou essentiellement identique.

- 10 **13.** Tube de lance (1) selon l'une quelconque des revendications précédentes sous la forme d'un tube de lance dans un chaufour, dans un brûleur de four à chaux, dans une injection de poudre de charbon de haut fourneau et dans des éléments de souffleur de suie.

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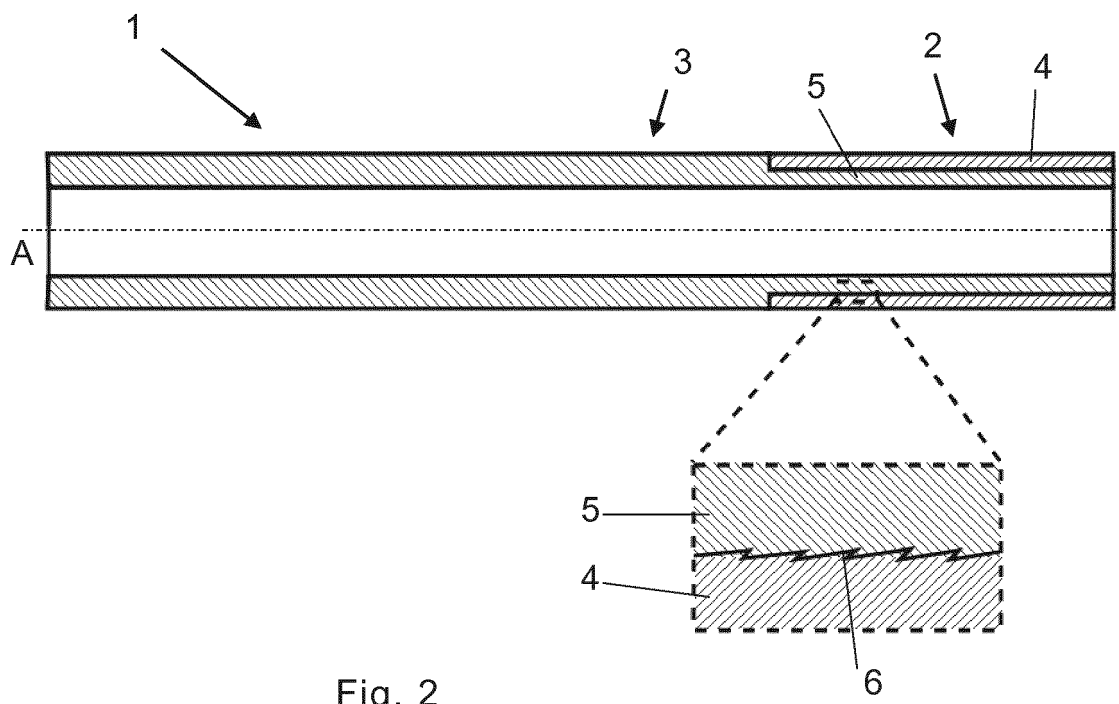
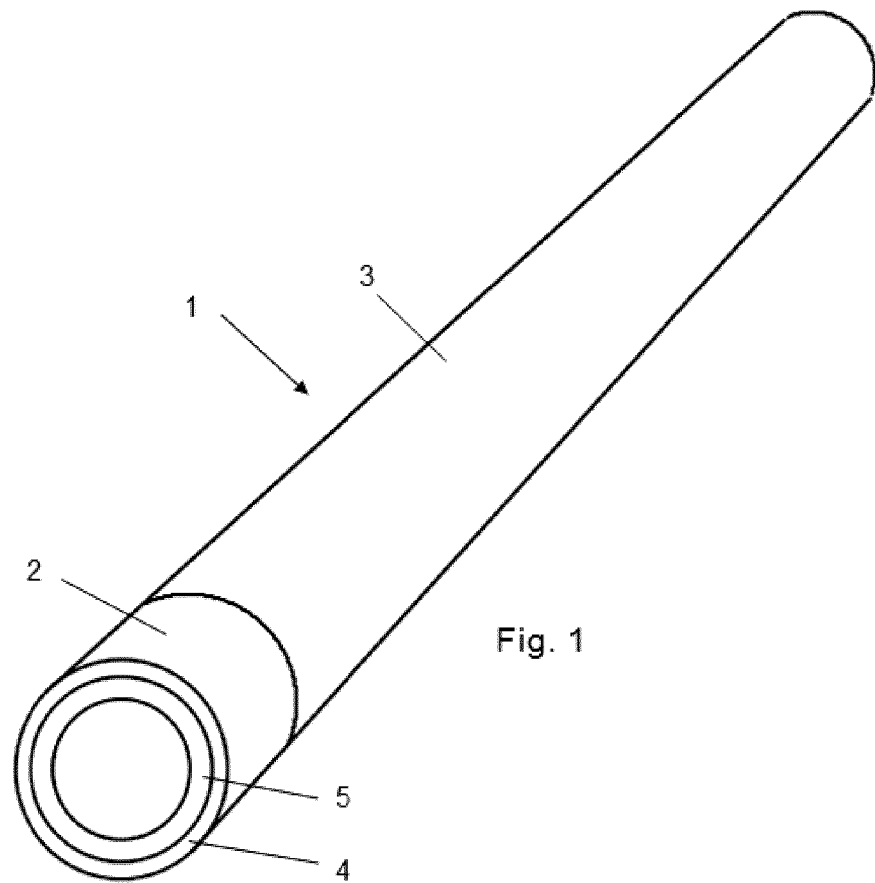
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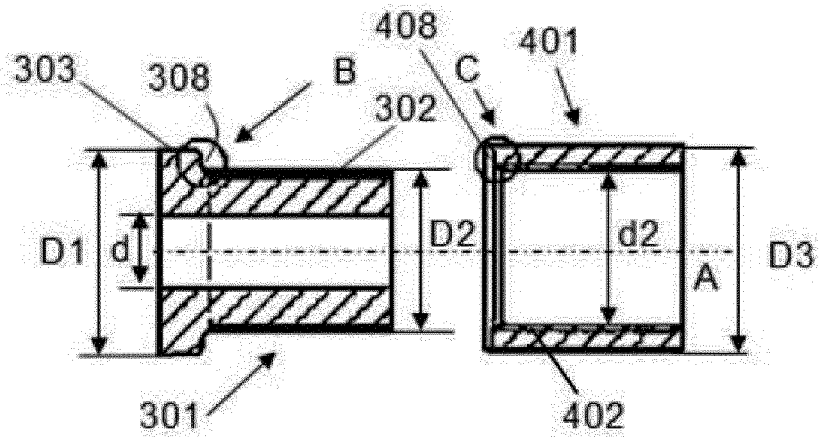


Fig. 3a

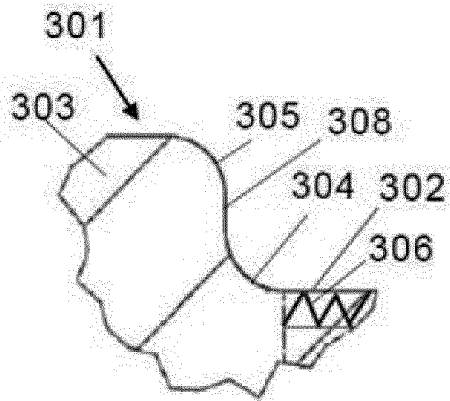


Fig. 3b

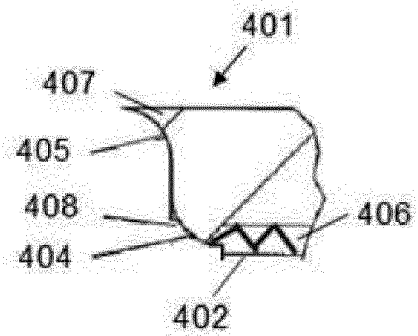


Fig. 3c

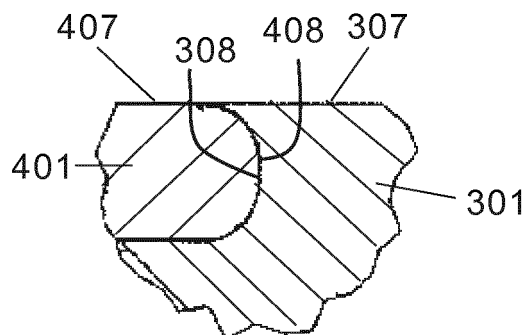


Fig. 4

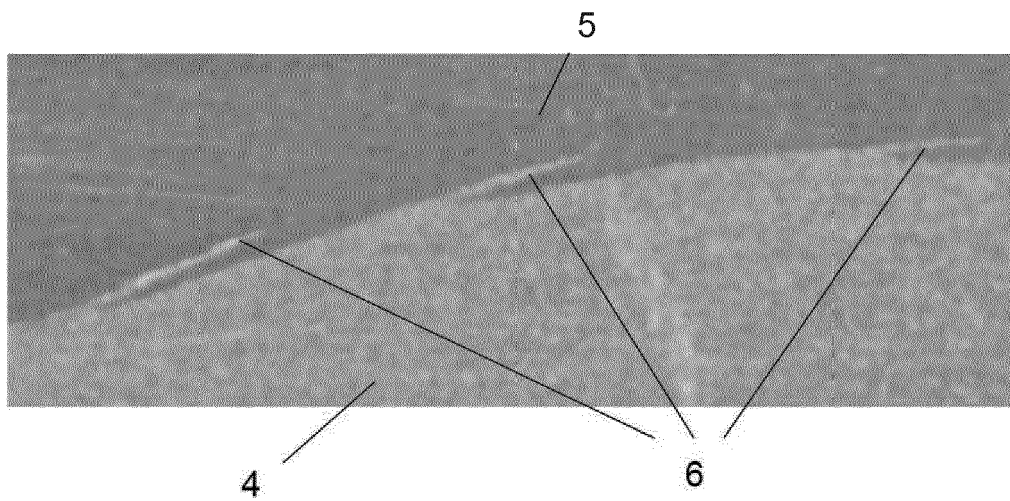
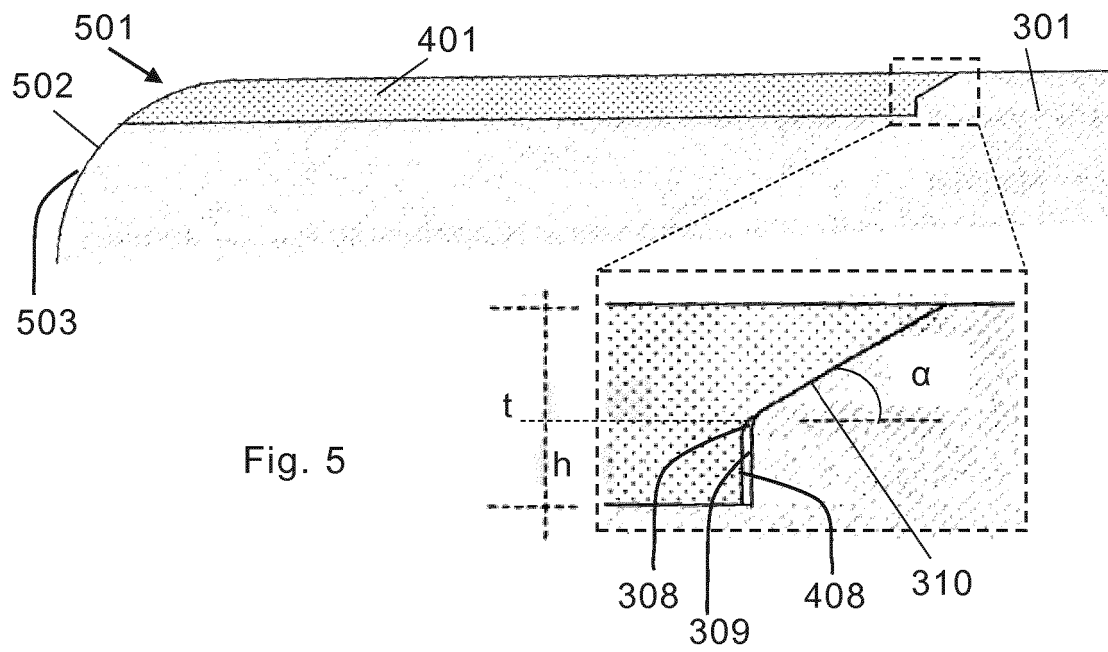


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1018563 A1 [0003]