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(54) **Procédé pour la préparation d'un ciment à haute teneur en alumine.**

(57) ABSTRACT: High alumina cement is produced in a submerged combustion melter, cooled and ground.

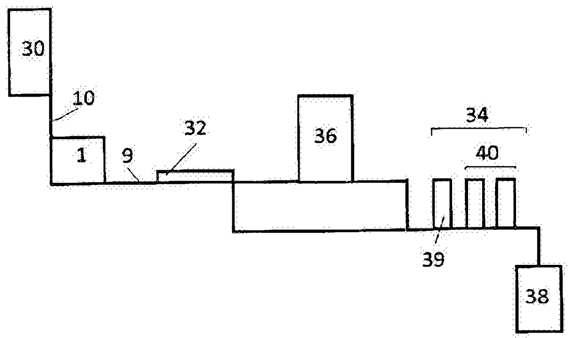



Fig 4

93214

# Process for the preparation of high alumina cement

The present invention relates to an improved process for the preparation of high alumina cement.

High alumina cement, also called aluminous cement or calcium aluminate cement, is produced by fusing a mixture of limestone and bauxite at high temperatures comprised between 1400 and 1600 °C, hence obtaining a melt which after cooling is ground to fine cement. The fusion may be performed in shaft furnaces, like blast furnaces, or in rotary kilns.

In typical formulations for the preparation of high alumina cement, the content of SiO2 may vary from 0.4 to 10.0 % by weight, Al2O3 may vary from 25 to 85 % by weight and CaO from 15 to 50 % y weight. High alumina cement may be used as hydraulic binder the preparation of concrete intended for construction purposes or in the manufacture of refractory elements. It may also be mixed with other cements for the preparation of cement blends showing specific properties. High alumina cement is known for its rapid strength development.

As can easily be understood, the production of high alumina cement requires high energy inputs, and there is an ever increasing need for improvement of the energy efficiency of the manufacturing process.

Moreover, because of the highly corrosive nature of the raw materials and melt to be treated, the refractory lining of the furnaces in which the high alumina cement is treated needs to be repaired or replaced after relatively short time periods. There is hence a need to find a way to overcome that technical problem.

It has been found that high alumina cement may advantageously be prepared in a submerged combustion melter. The invention process hence comprises introducing solid batch material for preparation of high alumina cement into a melter, melting the solid batch material in the melter by submerged combustion, discharging a liquid melt, cooling said discharged liquid melt to obtain solidified melt and grinding the solidified melt to appropriate grain size. The grinding step is known to the person skilled in the art and may be adapted to product quality demand and requirements of the market place.

Submerged combustion melters are known. These melters are characterized by the fact that they have one or more burner nozzles arranged below the surface of the melt, in a lance, in the melter walls and/or melter bottom, preferably in the melter bottom, such that the burner flame and/or combustion products pass through the melt and transfer energy directly to the melt.

Submerged combustion melters are known to generate high turbulence or agitation in the melt caused at least partially by the injection of combustion gas under high pressure into the melt and by the convective movements within the melt. The high turbulence ensures efficient mixing in the melt, and homogenizes the melt in terms of temperature profile and composition, leading to a high quality cement product. It also favors the absorption of raw material into the melt and improves heat transfer to fresh raw material. This reduces required residence time in the melter prior to withdrawal for downstream treatment. It is preferred, however, that the burners are controlled such that the melt volume is increased by at least 8%, preferably at least 10%, more preferably at least 15% or 20%, compared to the volume the melt would have with no burners firing. It is understood that the gas injection reduces the density of the melt, hence increases its volume, compared to what it would be when no gas is being injected.

In connection with the above, the melt volume (no submerged burners firing) may be calculated as a function of the temperature and the raw material batch composition. The level and hence volume of the agitated melt (submerged burners firing) may be measured with laser scanners or similar measuring devices that allow to measure and average melt level over a given period of time.

While submerged combustion has a tendency to cause foam formation at the top of the melt, that is over the melt level, it is preferable to operate the submerged combustion melter without foam or at reduced foam level, as the foam level may be disadvantageous with respect to the heat transfer.

Furthermore, the melting chamber walls may comprise double steel walls separated by circulating cooling liquid, preferably water. Particularly in the case of a cylindrical melting chamber, such assembly is relatively easy to build and is capable of resisting high mechanical stresses. A cylindrical shape of the melter facilitates balance of stresses on the outside wall. As the walls are cooled, for example water cooled, melt preferably solidifies and forms a protective layer on the inside of the melter wall. The melter assembly may not require any internal refractory lining and therefore needs less or less costly maintenance. In addition, the melt is not contaminated with undesirable components of refractory material normally eroded from an internal refractory lining. The internal face of the melter wall may advantageously be equipped with tabs or pastilles or other small elements projecting towards the inside of the melter. These may help in constituting and fixing a layer of solidified melt on the internal melter wall generating a lining having thermal resistance and reducing the transfer of heat to the cooling liquid in the double walls of the melter.

The melter may be equipped with heat recovery equipment. Hot fumes from the melter may be used to preheat raw material or the thermal energy contained in them may be recovered. Similarly, the thermal energy contained in the cooling liquid circulating between the two walls of the melter may also be recovered for heating or other purposes

Overall the energy efficiency of submerged combustion melters is significantly improved compared to conventional shaft melters or rotary kilns.

The raw materials may be loaded through an opening in the melter wall, above the melt surface. Said opening may be opened and closed, for example by a piston, to minimize escape of heat and fumes. Raw material may be prepared and loaded into an intermediate chute and subsequently fall into the melter, in an opposite direction to escaping fumes, onto the melt surface. This countercurrent flow may advantageously preheat the raw materials. In the alternative, the raw materials may be charged below the level of the melt, by way of a screw feeder or a hydraulic feeder.

Melt may be withdrawn continuously or batch wise from the melter. Where raw material is loaded close to the melter wall, the melt outlet is preferably arranged opposite the material inlet. In a preferred embodiment of the invention, the melt is withdrawn through a discharge opening controlled by, for example, a ceramic piston. The piston may open or close a sliding door covering or uncovering the discharge opening.

The submerged burners preferably inject high pressure jets of combustion products into the melt that is sufficient to overcome the liquid pressure and to create forced upward travel of the flame and combustion products. The speed of the combustion and/or combustible gases, notably at the exit from the burner nozzle(s), may be ≥ 60 m/s, ≥ 100 m/s or ≥ 120 m/s and/or ≤350 m/s, ≤330 m/s, ≤300 or ≤200 m/s. Preferably the speed of the *combustion* gases is in the range of about 60 to 300 m/s, preferably 100 to 200, more preferably 110 to 160 m/s.

The temperature of the melt may advantageously be between 1400°C and 1600°C; it may be at least 1450°C or 1480°C and/or no more than 1600°C or 1550°C or 1520 °C.

According to a preferred embodiment, the submerged combustion is performed such that a substantially toroidal melt flow pattern is generated in the melt, having a substantially vertical central axis of revolution, comprising major centrally inwardly convergent flows at the melt surface; the melt moves downwardly at proximity of the vertical central axis of revolution and is recirculated in an ascending movement back to the melt surface, thus defining an substantially toroidal flow pattern.

The generation of such a toroidal flow pattern ensures highly efficient mixing of the melt and absorption of raw material into the melt, and homogenizes the melt in terms of temperature profile and composition, thus leading to high quality final product.

Advantageously, the melting step comprises melting the solid batch material, in a submerged combustion melter by subjecting the melt to a flow pattern which when simulated by computational fluid dynamic analysis shows a substantially toroidal melt flow pattern in the melt, comprising major centrally inwardly convergent flow vectors at the melt surface, with the central axis of revolution of the toroid being substantially vertical.

At the vertical axis of revolution of said toroidal flow pattern, the flow vectors have a downward component reflecting significant downward movement of the melt in proximity of said axis. Towards the melter bottom, the flow vectors change orientation showing outward and then upward components.

Preferably the fluid dynamics model is code ANSYS R14.5, taking into consideration the multi-phase flow field ranging from solid batch material to liquid melt and gas generated in the course of the conversion, and the batch-to-melt conversion.

A toroidal melt flow pattern may be obtained using submerged combustion burners arranged at the melter bottom in a substantially annular burner zone imparting a substantially vertically upward directed speed component to the combustion gases. Advantageously, the burners are arranged with a distance between adjacent burners of about 250 - 1250 mm, advantageously 500 - 900 mm, preferably about 600 - 800, even more preferably about 650 - 750 mm. It is preferred that adjacent flames do not merge.

Each burner axis and/or a speed vector of the melt moving upwards over or adjacent to the submerged burners may be slightly inclined from the vertical, for example by an angle which is ≥1°, ≥2°, ≥3° or ≥5 and/or which is ≤ 30°, preferably ≤ 15°, more preferably ≤10°, notably towards the center of the melter. Such an arrangement may improve the flow and directs melt flow away from the outlet opening and/or towards a center of the melter thus favoring a toroidal flow and incorporation of raw material in to the melt.

According to a one embodiment, each central burner axis is inclined by a swirl angle with respect to a vertical plane passing through a central vertical axis of melter and the burner center. The swirl angle may be ≥1°, ≥2°, ≥3°, ≥5° and/or ≤ 30°, ≤ 20°, ≤ 15° or ≤ 10°. Preferably, the swirl angle of each burner is about the same. Arrangement of each burner axis at a swirl angle imparts a slightly tangential speed component to the upward blowing flames, thus imparting a swirling movement to the melt, in addition to the toroidal flow pattern.

The burner zone is defined as a substantially annular zone. Burner arrangements, for example on an elliptical or ovoid line within the relevant zone are possible, but the burners are preferably arranged on a substantially circular burner line.

Preferably, the flow pattern comprises an inwardly convergent flow at the melt surface followed by a downwardly oriented flow in proximity of the central axis of revolution of the toroid. Said central axis of revolution advantageously corresponds to the vertical axis of symmetry of the melter. By axis of symmetry is meant the central axis of symmetry and, if the melter shows a transversal cross-section which does not have any single defined axis of symmetry, then the axis of symmetry of the circle in which the melter section is inscribed. The downwardly oriented flow is followed by an outwardly oriented flow at the bottom of the melter and a substantially annular upward flow at proximity of the burners, reflecting recirculation of melt toward the burner zone and in an ascending movement back to the melt surface, thus defining a substantially toroidal flow pattern.

The inwardly convergent flow vectors at the melt surface advantageously show a speed comprised between 0.1-3 m/s. The downward oriented speed vectors at proximity of the vertical central axis of revolution are preferably of significant magnitude reflecting a relatively high speed of material flowing downwardly. The downward speed vectors may be between 0.1-3 m/s. The melt and/or the raw materials within the melter, at least at one portion of the melter and notably at the melt surface (particularly inwardly convergent flow vectors at the melt surface) and/or at or proximate a vertical central axis of revolution, may reach a speed which is ≥0.1 m/s, ≥0.2 m/s, ≥0.3 m/s or ≥0.5 m/s and/or which is ≤2.5 m/s, ≤2 m/s, ≤1.8 m/s or ≤1.5 m/s.

The preferred toroidal flow pattern ensures highly efficient mixing and homogenizes the melt in terms of temperature profile and composition. It also favors the absorption of raw material into the melt and improves heat transfer to fresh raw material. This reduces required residence time in the melter prior to withdrawal, while avoiding or at least reducing the risk of raw material short cutting the melt circulation.

In one preferred embodiment, the burners are arranged at a distance of about 250 - 750 mm from the side wall of said melting chamber; this favors the preferred flow described above and avoids flame attraction to the melting chamber side walls. Too small a distance between burners and side wall may damage or unnecessarily stress the side wall. While a certain melt flow between burner and wall may not be detrimental and may even be desirable, too large a distance will tend to generate undesirable melt flows and may create dead zones which mix less with the melt in the center of the melter and lead to reduced homogeneity of the melt.

The distance between submerged burners is advantageously chosen such as to provide the desired toroidal flow pattern within the melt but also to avoid that adjacent flames merge. While this phenomenon depends on many parameters such as temperature and viscosity of the melt, pressure and other characteristics of the burners, it has been found advantageous to select a burner circle diameter comprised between about 1200 and 2000 mm. Depending on burner type, operating pressure and other parameters, too large a diameter will lead to diverging flames; too narrow a diameter will lead to merging flames.

Preferably at least 6 burners are provided, for example arranged on a burner circle line, more preferably 6 to 10 burners, even more preferably 6 to 8 burners, depending on the melter dimensions, burner dimensions, operating pressure and other design parameters.

Each burner or each of a plurality of a group of burners, for example opposed burners, may be individually controlled. Burners close to a raw material discharge may be controlled at different, preferably higher gas speeds and/or pressures than adjacent burners, thus allowing for improved heat transfer to the fresh raw material that is being loaded into the melter. Higher gas speeds may be required only temporarily, that is, in the case of batch wise loading of fresh raw material, just during the time period required for absorption of the relevant load into the melt contained in the melter. It may also be desirable to control burners that are located close to a melt outlet at a lower gas speed/pressure in order not to disturb the outlet of the melt.

The melting chamber is preferably substantially cylindrical in cross section; nevertheless, it may have an elliptical cross section or polygonal cross section showing more than 4 sides, preferably more than 5 sides.

It has been found that the melt for the preparation of high alumina cement shows a tendency to crystallize rather quickly. It may thus be desirable to discharge the melt quickly for downstream solidification and grinding. Such discharge may preferably be carried out through an outlet opening which may be opened and closed by a sliding door controlled by a piston.

The composition of the melt produced may typically comprise:

| | Possible melt composition (% weight) |
|---|---|
| $SiO_2$ | 4.0 |
| $Al_2O_3$ | 39.4 |
| CaO | 38.4 |
| $Fe_2O_3$ (total iron) | 16.4 |
| MgO | 1.0 |
| Na2O | 0.1 |
| K2O | 0.2 |
| TiO2 | 1.9 |
| other | Rest to 100% |

The discharged melt is allowed to cool at suitable temperature for storage and/or grinding. Grinding may be operated in several stages as is known per se. A first grinding step may break the cooled solidified melt particles down to a particle size suitable for supply into a grinder that will finally reduce the particle size such that 100% thereof pass a 90 µm screen in a dry circuit, possibly in several stages. Equipment for carrying out said grinding operations are known in the art and will not be further detailed herein.

An embodiment of a melter suitable for use in accordance with the present invention is described below, with reference to the appended drawings of which:

- Figures 1a and 1b are schematic representations of a toroidal flow pattern in a submerged combustion melter;
- Figure 2 shows a vertical section through a submerged combustion melter;
- Figure 3 is a schematic representation of a burner layout for a melter of Fig. 2; and
- Figure 4 schematically shows a production line according to the invention.

With reference to the figures, a toroidal flow pattern is preferably established in which melt follows an ascending direction close to submerged burners 21, 22, 23, 24, 25, 26 which are arranged on a circular burner line 27, flows inwardly towards the center of the circular burner line at the melt surface, and flows downwards in the proximity of the said center. The toroidal flow generates agitation in the melt, ensures good stirring of the melt, and absorption of raw material into the melt. Furthermore, it has been determined that the flow as generated also reduces foam generation at the top of the melt; the gas or foam bubbles being entrained back into the melt, thus reducing its density.

The illustrated melter 1 comprises: a cylindrical melting chamber 3 having an internal diameter of about 2.0 m which contains the melt; an upper chamber 5; and a chimney for evacuation of the fumes. The upper chamber 5 is equipped with baffles 7 that prevent any melt projections thrown from the surface 18 of the melt being entrained into the fumes. A raw material feeder 10 is arranged at the upper chamber 5 and is designed to load fresh raw material into the melter 1 at a point 11 located above the melt surface 18 and close to the side wall of the melter. The feeder 10 comprises a horizontal feeding means, for example a feed screw, which transports the raw material mix to a hopper fastened to the melter, the bottom of which may be opened and closed by a vertical piston. The bottom of the melting chamber comprises six submerged burners 21, 22, 23, 24, 25, 26 arranged on a circular burner line 27 concentric with the melter axis and having a diameter of about 1.4 m. The melt may be withdrawn from the melting chamber 3 through a controllable outlet opening 9 located in the melting chamber side wall, close to the melter bottom, substantially opposite the feeding device 10. The melt withdrawn from the melter may then be allowed to cool and subsequently ground as required.

The temperature within the melt may be between 1400°C and 1600°C, preferably 1450°C and 1550°C, depending on the composition of the melt, desired viscosity and other parameters. Preferably, the melter wall is a double steel wall cooled by a cooling liquid, preferably water. Cooling water connections provided at the external melter wall allow a flow sufficient to withdraw energy from the inside wall such that melt can solidify on the internal wall and the cooling liquid, here water, does not boil.

The submerged burners 21,22,23,24,25,26 comprise concentric tube burners operated at gas flows of 100 to 200 m/s, preferably 110 to 160 m/s and generate combustion of fuel gas and oxygen containing gas within the melt. The combustion and combustion gases generate agitation within the melt before they escape into the upper chamber and then through the chimney. These hot gases may be used to preheat the raw material and/or the fuel gas and/or oxidant gas (eg oxygen, industrial oxygen have an oxygen content ≥ 95% by weight or oxygen enriched air) used in the burners. The fumes are preferably filtered prior to release to the environment, optionally using dilution with ambient air to reduce their temperature prior to filtering.

With reference to Fig. 4, raw material from a raw material storage 30 is charged into the furnace 1 as described above, and withdrawn thereof for cooling 32 and further downstream treatments known per se. The discharged melt is allowed to cool at a temperature suitable for further downstream operation, including grinding 34 to appropriate grain size and/or storing 36,38. The grinding is advantageously effected in several stages, including a first stage 39 that reduces the particle size of the solidified melt to a size suitable for downstream fine grinding 40 which in turn may be carried out in a manner known per se, in several stages, in order to reach a particle size as is common in the cement manufacturing industry. Mostly the final grain size is a powdery grain size. For example, it is such that 100% of the particles pass a 90 µm screen in a dry circuit. The production line further comprises dryers as appropriate and as is known per se; these devices have not been shown in the figures.

With respect to the exemplified melter, it has been found that the turbulent aerated melt showed almost no foam floating at the top of the melt, and it has been determined that the turbulent aerated melt showed a volume (averaged over a 1 minute time period) of 30 - 50% higher than that calculated on the basis of the raw material fed into the melter and maintained at the same temperature. The volume was.

The high alumina cement obtained is of high quality. The above described production process is less energy demanding then known processes, because of the choice of submerged combustion melters that allow for improved energy transfer to the melt, shorter residence times and thus less heat loss, and because the high stirring leads to a more homogenous melt at reduced melt viscosity, which in turn may allow for operation at reduced temperatures. Furthermore, submerged combustion may advantageously be performed in water-cooled melters which are more easy and less costly to maintain and repair and which further allow for recycling of the energy withdrawn from the cooling fluid.

## Revendications

1. Procédé pour la préparation de ciment à haute teneur en alumine comportant :
   - l'introduction dans un four à fusion d'une charge solide pour la préparation de ciment à haute teneur en alumine ;
   - la fusion de la charge solide par combustion submergée dans le four à fusion afin de former un bain fondu liquide ;
   - la soustraction d'au moins une partie du bain fondu liquide du four à fusion ; et
   - le broyage du bain fondu solidifié à granulométrie appropriée.

2. Procédé selon la revendication 1 dans lequel les parois de la chambre de fusion sont refroidies, par exemple moyennant de doubles parois en acier séparées par du liquide de refroidissement en circulation, de préférence de l'eau, et ne sont pas couvertes d'un revêtement réfractaire.

3. Procédé selon la revendication 1 ou 2 dans lequel de la chaleur est récupérée des fumées chaudes et/ou du liquide de refroidissement.

4. Procédé selon l'une des revendications 1 à 3 dans lequel de la chaleur est récupérée des fumées chaudes afin de préchauffer les matières premières.

5. Procédé selon l'une des revendications 1 à 4 dans lequel une partie au moins du bain fondu est soutirée du four de fusion de manière continue ou discontinue.

6. Procédé selon l'une des revendications précédentes dans lequel les brûleurs submergés du four de fusion sont commandés de telle sorte que le volume du bain fondu est accru d'au moins 8 %, de préférence d'au moins 10 %, plus particulièrement d'au moins 15 % ou 20 %, par rapport au volume que le bain fondu aurait sans que les brûleurs ne brûlent.

7. Procédé selon l'une des revendications 1 à 6 dans lequel la combustion submergée est effectuée de sorte à générer une configuration de flux substantiellement toroïdale dans le bain fondu, ladite configuration toroïdale du flux ayant un axe central de révolution substantiellement vertical, comprenant à la surface du bain fondu des flux orientés en majeure partie vers l'intérieur et le centre ; dans lequel le bain fondu se déplace vers le bas à proximité de l'axe central vertical de révolution et est renvoyé en un mouvement

ascendant vers la surface du bain fondu, définissant ainsi une configuration de flux substantiellement toroïdale.

8. Procédé selon l'une des revendications 1 à 7 dans lequel l'étape de fusion comprend la fusion de la charge solide dans un four à fusion par combustion submergée, en soumettant le bain fondu à une configuration de flux qui, lorsqu'elle est simulée par ordinateur moyennant analyse de la dynamique des fluides, est substantiellement toroïdale, comprenant à la surface du bain fondu des vecteurs de flux orientés en majeure partie vers l'intérieur et le centre, et l'axe central de révolution du toroïde étant substantiellement vertical.

9. Procédé selon la revendication 8 dans lequel les vecteurs de flux changent d'orientation dans le fond du four de fusion, présentant des composantes orientées vers l'extérieur et ensuite vers le haut.

10. Installation de production pour la préparation de ciment à haute teneur en alumine comportant (i) un four de fusion à combustion submergée (1) comprenant une chambre de fusion (3), des parois (19) et un fond de chambre de fusion, des brûleurs submergés (21,22,23,24,25,26), et équipé d'un dispositif de déchargement (10) ou d'alimentation en matières premières et d'un soutirage de bain fondu (9), (ii) un étage de refroidissement du bain fondu et (iii) un étage de broyage.

11. Installation de production selon la revendication 10 dans laquelle les parois (19) de la chambre de fusion sont refroidies, par exemple moyennant de doubles parois en acier séparées par du liquide de de refroidissement en circulation, de préférence de l'eau, qui ne sont pas couvertes d'un revêtement réfractaire.

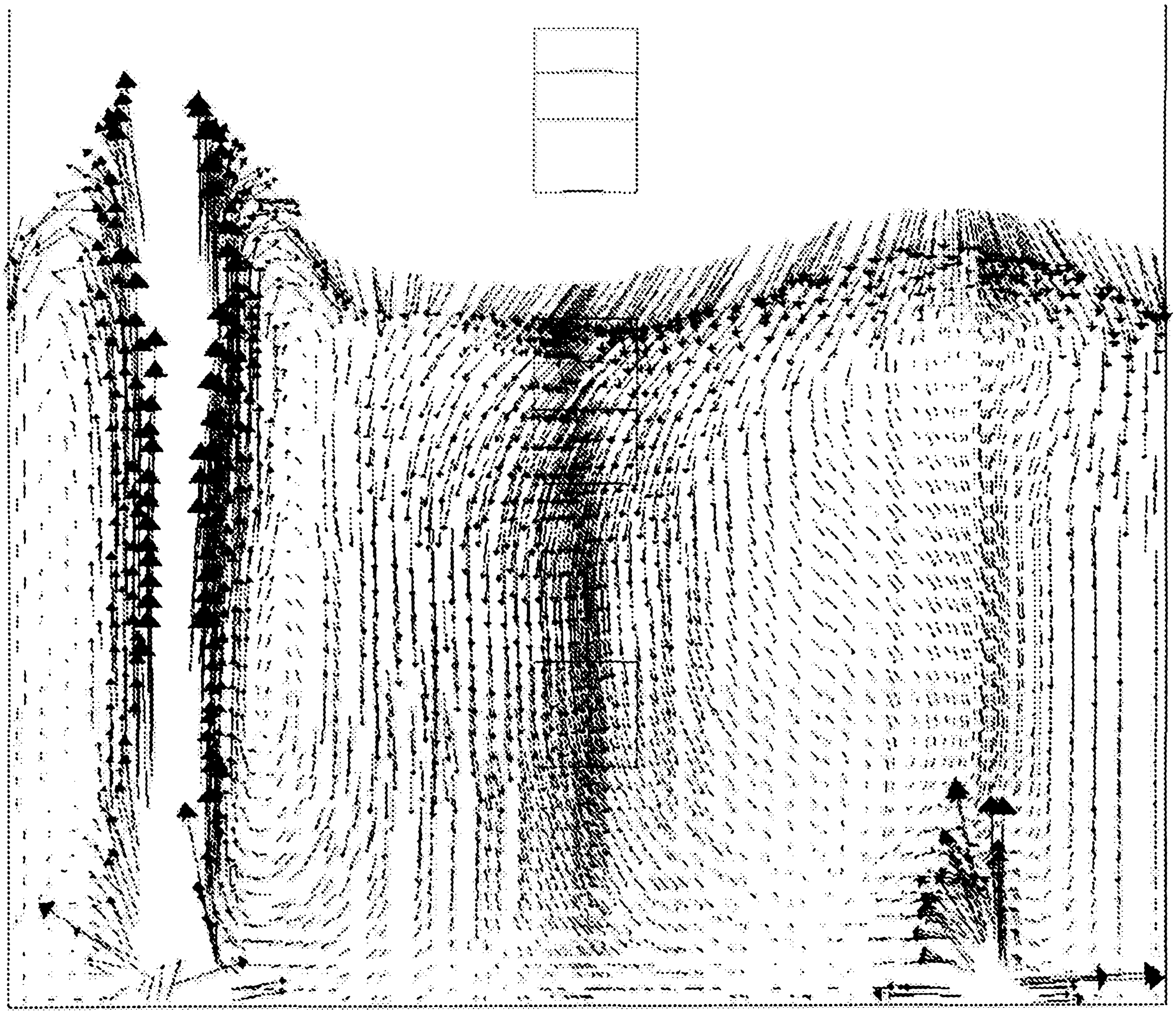
12. Installation de production selon l'une des revendications 10 ou 11 dans laquelle les brûleurs à combustion submergée (21,22,23,24,25,26) sont agencés au fond du four de fusion, dans une zone de brûleurs substantiellement annulaire, de préférence sur une cercle de brûleurs (27).

13. Installation de production selon l'une des revendications 10 à 12 dans laquelle les brûleurs (21,22,23,24,25,26) sont agencés à une distance entre brûleurs adjacents d'environ 250 à 1250 mm, avantageusement de 500 à 900 mm, de préférence d'environ 600 à 800 ou plus particulièrement d'environ 650 à 750 mm.

14. Installation de production selon l'une des revendications 10 à 13 dans laquelle chaque axe de brûleur et/ou un vecteur de vitesse du bain fondu en mouvement ascendant au-dessus ou à proximité des brûleurs submergés (21,22,23,24,25,26) est légèrement incliné par rapport à la verticale, par exemple d'un angle ≥1°, ≥2°, ≥3° ou ≥5 et/ou ≤30°, de préférence ≤15°, plus particulièrement ≤10°, notamment vers le centre du four de fusion.

15. Installation de production selon l'une des revendications 10 à 14 dans laquelle chaque axe central de brûleur est incliné d'un angle de turbulence par rapport à un plan vertical qui passe à travers un axe vertical central du four de fusion et le centre du brûleur, l'angle de turbulence étant ≥1°, ≥2°, ≥3°, ≥5° et/ou ≤30°, ≤20°, ≤15° ou ≤10°.

Fig. 1a



# Fig 1B

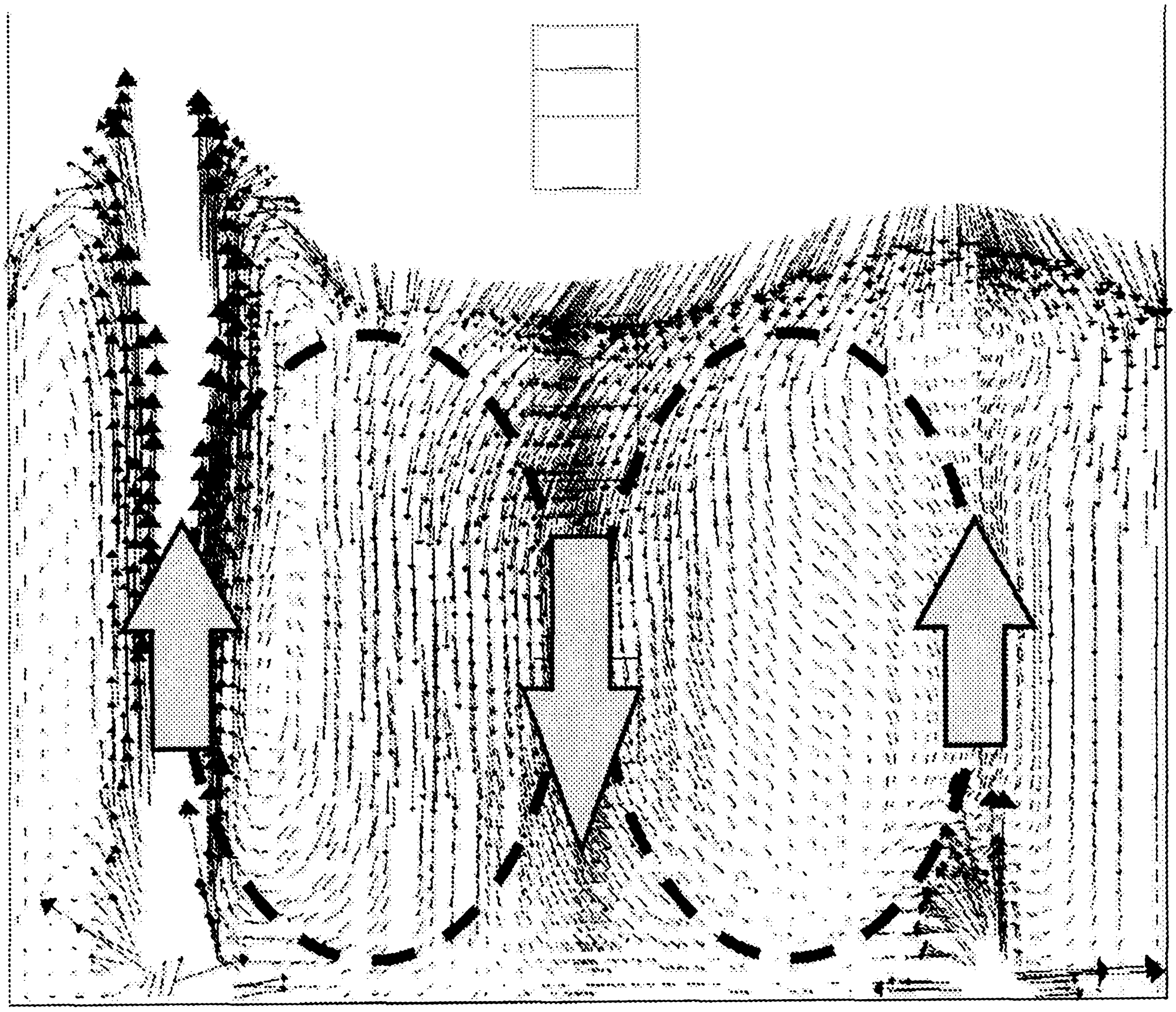


Fig 2

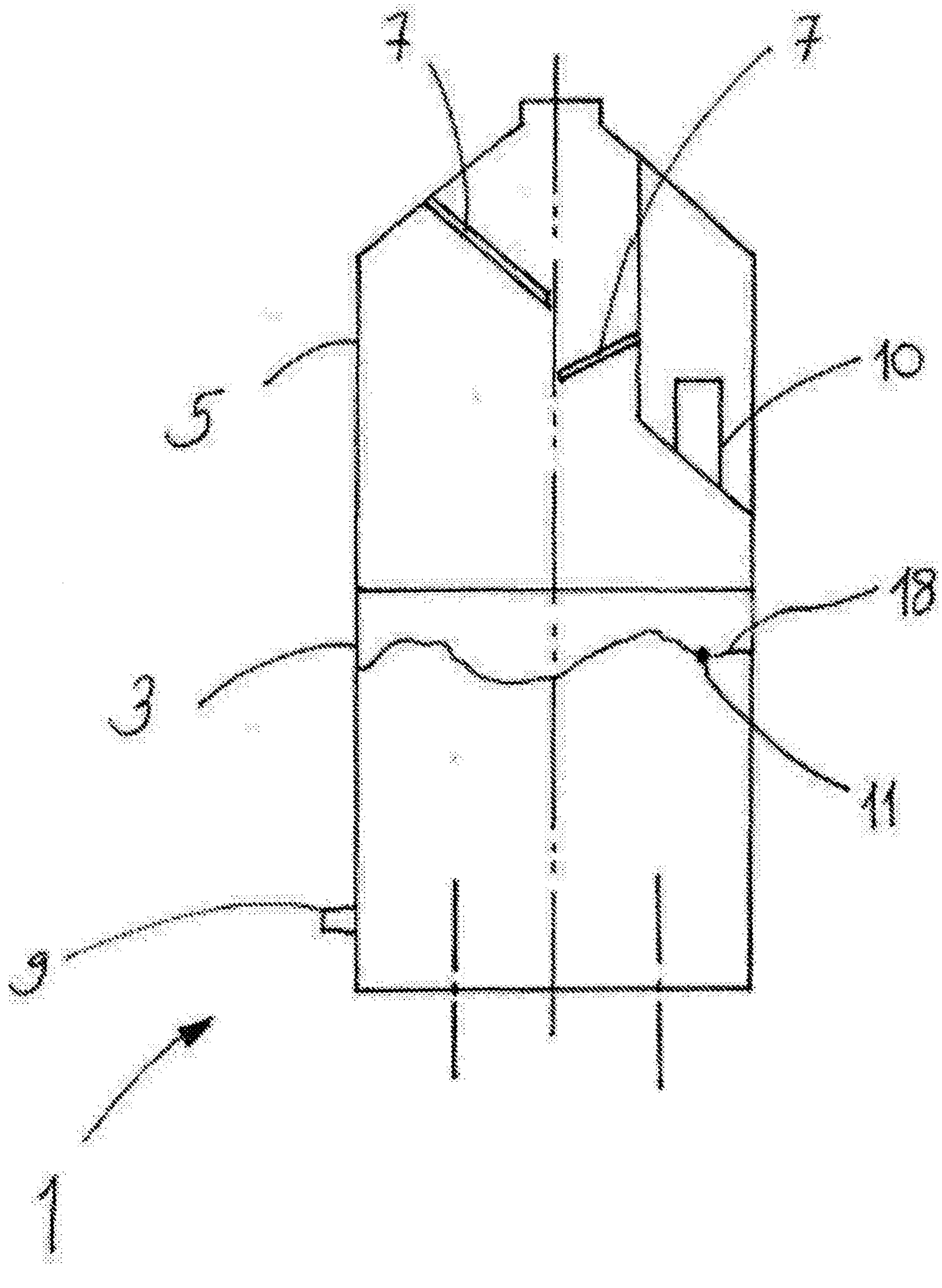
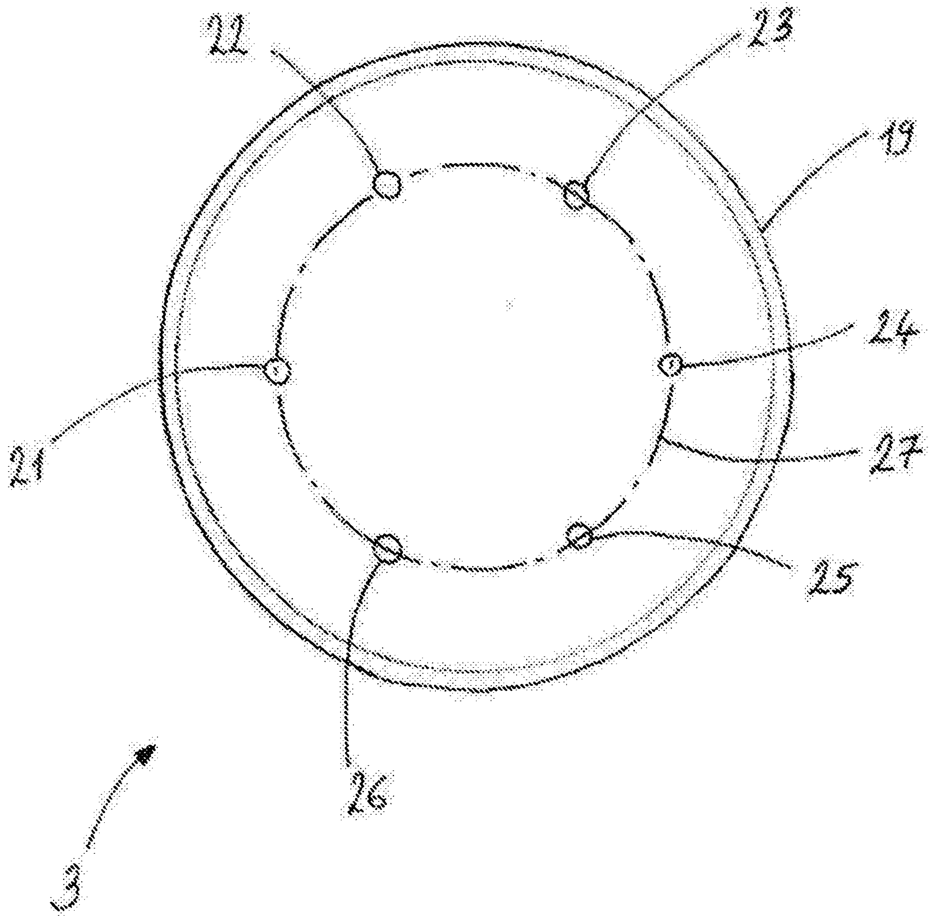


Fig 3



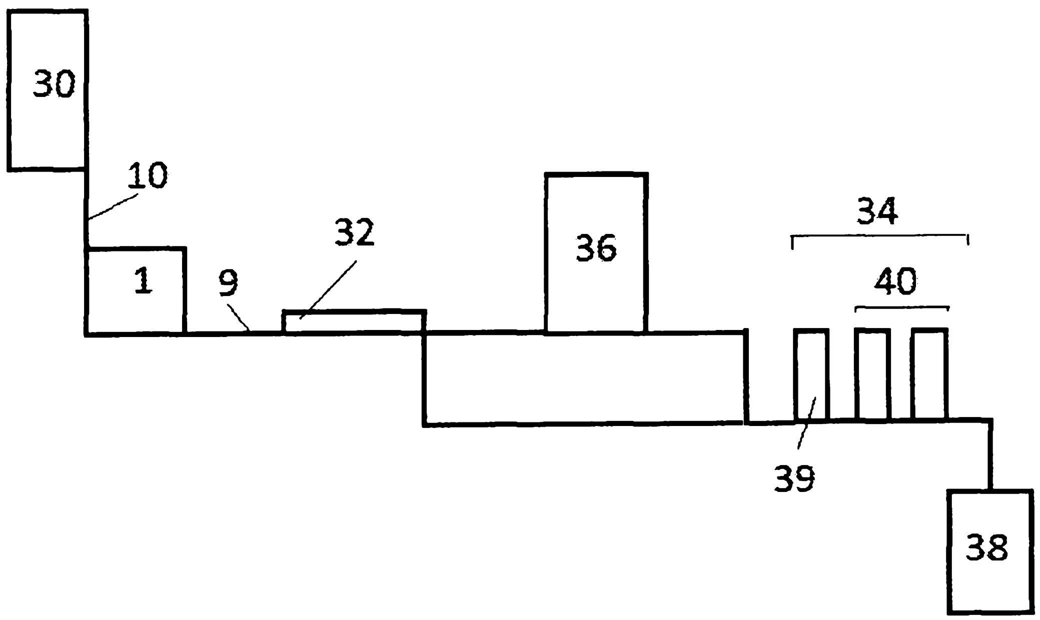



Fig 4

ABSTRACT

High alumina cement is produced in a submerged combustion melter, cooled and ground.

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference<br>P0708/PCT | **FOR FURTHER ACTION** see Form PCT/ISA/220 as well as, where applicable, item 5 below. | |
|---|---|---|
| International application No.<br>PCT/EP2016/051731 | International filing date *(day/month/year)*<br>27 January 2016 (27-01-2016) | (Earliest) Priority Date *(day/month/year)*<br>27 January 2015 (27-01-2015) |
| Applicant<br>KNAUF INSULATION | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into ____________, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. [ ] **Certain claims were found unsearchable** (See Box No. II)
3. [ ] **Unity of invention is lacking** (see Box No III)
4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority
6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 4
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. C04B7/32 C04B7/44 C03B5/235
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
C04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | CN 101 811 838 B (SICHUAN CHUANHENG CHEMICAL CORP) 3 September 2014 (2014-09-03) abstract; claims 1-5; examples 1-3 | 1-15 |
| X | US 2004/035330 A1 (OATES DAVID BRIDSON [CA] ET AL) 26 February 2004 (2004-02-26) paragraphs [0057], [0058], [0089] - [0093] | 10-15 |
| A | WO 2009/091558 A1 (GAS TECHNOLOGY INST [US]; RUE DAVID M [US]; ARONCHIK GRIGORY I [RU]; K) 23 July 2009 (2009-07-23) the whole document | 1-15 |

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 April 2016 | 02/05/2016 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Roesky, Rainer |

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | wikipedia: "Calcium Aluminate Cements", , 8 October 2014 (2014-10-08), XP002755941, Retrieved from the Internet: URL:https://en.wikipedia.org/wiki/Calcium_aluminate_cements [retrieved on 2016-03-30] the whole document ----- | 1-15 |

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# INTERNATIONAL SEARCH REPORT

**Information on patent family members**

International application No
PCT/EP2016/051731

| Patent document cited in search report | | Publication date | Patent family member(s) | | Publication date |
|---|---|---|---|---|---|
| CN 101811838 | B | 03-09-2014 | NONE | | |
| US 2004035330 | A1 | 26-02-2004 | CA 2438053 | A1 | 26-02-2004 |
| | | | US 2004035330 | A1 | 26-02-2004 |
| WO 2009091558 | A1 | 23-07-2009 | US 2011236846 | A1 | 29-09-2011 |
| | | | WO 2009091558 | A1 | 23-07-2009 |

**Information on Search Strategy** - Pilot phase (see OJ 2015, A86)
The type of information contained in this sheet may change during the pilot for improving the usefulness of this new service.

Application Number
PCT/EP2016/051731

TITLE: PROCESS FOR THE PREPARATION OF HIGH ALUMINA CEMENT

APPLICANT: KNAUF INSULATION

IPC CLASSIFICATION: C04B7/32, C04B7/44, C03B5/235

EXAMINER: Roesky, Rainer

CONSULTED DATABASES: CIS, EPODOC, WPI

CLASSIFICATION SYMBOLS DEFINING EXTENT OF THE SEARCH:

IPC:

CPC: C04B28/02, C04B7/32, C04B7/4484

FI/F-TERMS:

KEYWORDS OR OTHER ELEMENTS FEATURING THE INVENTION:

# PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

# PCT

## WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
*(day/month/year)* see form PCT/ISA/210 (second sheet)

| | |
|---|---|
| Applicant's or agent's file reference<br>see form PCT/ISA/220 | **FOR FURTHER ACTION**<br>See paragraph 2 below |

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| PCT/EP2016/051731 | 27.01.2016 | 27.01.2015 |

International Patent Classification (IPC) or both national classification and IPC
INV. C04B7/32 C04B7/44 C03B5/235

Applicant
KNAUF INSULATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

| Name and mailing address of the ISA: | Date of completion of this opinion | Authorized Officer |
|---|---|---|
| European Patent Office<br>D-80298 Munich<br>Tel. +49 89 2399 - 0<br>Fax: +49 89 2399 - 4465 | see form PCT/ISA/210 | Roesky, Rainer<br>Telephone No. +49 89 2399-0 |

**Box No. I Basis of the opinion**

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

**Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | 2, 6-9, 11-15 |
| | No: | Claims | 1, 3-5, 10 |
| Inventive step (IS) | Yes: | Claims | |
| | No: | Claims | 1-15 |
| Industrial applicability (IA) | Yes: | Claims | 1-15 |
| | No: | Claims | |

2. Citations and explanations

**see separate sheet**

**Box No. VIII Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

**see separate sheet**

## Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1 **Reference is made to the following documents:**

D1 DATABASE WPI
Thomson Scientific, London, GB;
AN 2010-L98172
& CN 101 811 838 B (SICHUAN CHUANHENG CHEMICAL) 3 September 2014 (2014-09-03)

D2 US 2004/035330 A1 (OATES DAVID BRIDSON [CA] ET AL) 26 February 2004 (2004-02-26)

2 **The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 3-5, 10 is not new in the sense of Article 33(2) PCT.**

2.1 The document D1 discloses (the references in parentheses applying to this document) a process for the preparation of high alumina cement comprising:

- introducing a solid batch material for preparation of high alumina cement (see examples, Tables) into a melter (claim 1)
- melting the solid batch material in the melter by submerged combustion to form a liquid melt (claim 1)
- withdrawing at least a portion of the liquid melt from the melter (claim 1)
- cooling said discharged liquid melt to obtain solidified melt (claim 1) and
- grinding the solidified melt to appropriate grain size (claim 1)

Hence, the subject-matter of claim 1 is not new.

2.2 The document D1 discloses (the references in parentheses applying to this document) the production equipment for the preparation of high alumina cement comprising a submerged combustion melter comprising melting chamber walls and a melting chamber bottom, submerged burners and equipped with a raw material discharge or feeder and melt outlet, a melt cooling station and a grinding station (mostly implicit)

The document D2 also discloses a similar device (§58, 89,91,92,93).

Hence, the subject-matter of claim 10 is not new.

2.3 Dependent claims 3-5 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty because D1 also discloses

a process

- wherein heat is recovered from the hot fumes to preheat the raw materials (claim 5)
- wherein part at least of the melt is withdrawn continuously or batchwise from the melter (implicit)

3 **The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 2, 6-9 and 11-15 does not involve an inventive step in the sense of Article 33(3) PCT.**

3.1 Dependent claims 2, 6-9 and 11-15 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step because none of the feature of these claims seems to be linked to a technical effect. Notably the geometry of the burner and the flow pattern have not been compared to the prior art and therefore it has not been shown how these can be advantageous.

The objective of D1 and also of D2 is the reduction of energy needed for the process (D1: abstract; D2: §57) which is the same as the objective of the current application (page 1: §4). Hence, it is not shown which features of the application lead to an improved if at all energy savings compared to the prior art.

## Re Item VIII

**Certain observations on the international application**

1 **The application does not meet the requirements of Article 6 PCT, because claim 6, 11, 13, 14 is not clear.**

1.1 Claim 6 does not meet the requirements of Article 6 PCT because the matter for which protection is sought is not clearly defined. The claim attempts to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

1.2 The term "towards the melter bottom" used in claim 9 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT.

1.3 Claim 11 is includes a method feature ("are cooled") in an product claim.

1.4 The term "substantially annular" used in claim 12 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT.

1.5 The term "about" used in claim 13 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT.

1.6 The term "slightly inclined" used in claim 14 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT.

1.7 The term "incorporated herein by reference" used in the description, page 1, is not recognized and therefore should be deleted from the description. If the matter in the document referred to is essential to the application then the matter should be expressly incorporated into the description, because the patent specification should regarding the essential features of the invention, be self-contained, i.e. capable of being understood without reference to any other document.