

LOW EMISSION PRODUCTION PROCESS OF SCM

The present invention relates to a method for simultaneous production of separate flows of cement clinker and supplementary cementitious material (SCM), respectively, where cement raw materials are preheated in a preheater, calcined in a calciner, burned into cement clinker in a kiln and cooled in a clinker cooler, and where SCM raw materials are heated to a temperature of at least 500 °C subject to heat exchange with hot gases and subsequently separated from the hot gases. Further, the invention relates to a plant for carrying out the method according to the invention.

It is generally accepted that the carbon footprint of cement production must be reduced, and energy savings as well as reduction of the clinker factor are accepted solutions within the cement business. Supplementary Cementitious Materials (SCM), hereunder artificial pozzolans produced by thermal treatment of geological raw materials or similar mineral waste materials like clay, shale, etc. are suitable means to reduce the clinker factor and the specific energy consumption on cement basis.

Traditionally, the cement clinker and SCM are produced in separate installations and mixed in desired proportions at a later stage. Today, both installations for the production of cement clinker and SCM have been optimized in terms of energy consumption and other process and product parameters, however, the production of SCM, when heating clays or other materials getting pozzolanic properties when properly heat treated, is typically associated with emission of gaseous species that are harmful to the environment. Basically, these species can be put into three categories:

- Carbon containing species, which are emitted due to evaporation, cracking and/or partial oxidation, including CO.
- Acidic gases like SO_2/SO_3 , HCl, H_2S
- NH_3 and/or volatile NH_4^+ -compounds

Release of these compounds to the environment must be avoided in an acceptable process and therefore traditional installations for the production of

SCM must be supplied with rather expensive equipment for cleaning the exhaust gases before emitted to the atmosphere.

It is the objective of the present invention to provide a method as well as a plant
5 for simultaneous production of separate flows of cement clinker and SCM, respectively, whereby the mentioned disadvantage is eliminated or at least significantly reduced.

According to the present invention this is achieved by a method of the kind
10 mentioned in the introduction, and being characterized in that the hot gases separated from the heated SCM raw materials are directed into the calciner.

It is hereby obtained that the environmental harmful gaseous species released from the SCM production process are effectively immobilised and/or destroyed in
15 the calciner, thus eliminating the need of costly cleaning equipment. This is due to the fact that the combustible emission compounds, being organic compounds, carbon monoxide, ammonia, etc., are effectively combusted in the calciner and the acidic emission compounds, being SO_2/SO_3 , HCl , H_2S , are effectively scrubbed by reacting with the alkaline dust present in the calciner. Also,
20 ammonium compounds and to some extent NO will be destroyed in the calciner. Furthermore, the heat of reaction released by the combustion of the emission compounds is released in the calciner and therefore fully utilised to lower the overall fuel consumption. Thus, by combining the two per se known production processes of cement clinker and SCM, respectively, in the described way, a both
25 energy efficient and low emission process is obtained for the simultaneous production of a high quality SCM product and cement clinker.

The SCM raw materials may be heated to the required temperature in any appropriate manner, such as by heat exchange with hot gases in counter-current
30 mode, where the hot gases and the material to be heated flow in opposite directions, such as in e.g. a rotary kiln. However, the activity and thus the maximum allowed proportion of the produced SCM in the mixed cement product strongly depend on the specific conditions of the thermal treatment. If the SCM

precursor has been nodulized by the movement in a rotary kiln and is subjected to a flame or another high-temperature source there is a great risk that a thermal gradient will occur in the individual SCM nodules or particles, where the outer surface is scorched while the inner core is unprocessed. Provided the heated
5 material is subjected to a comminution process prior to use as cement and/or concrete constituent, then the un-calcined inner material is exposed resulting in increased water demand and associated lowering of the cement strengths. Therefore, it is preferred that the SCM raw materials are heated to the required temperature by heat exchange with hot gases in co-current mode, where the hot
10 gases and the materials to be heated flow in same direction, such as in a gas suspension reactor. Hereby, a more effective control of the SCM heating process may be obtained, thus resulting in a higher quality product.

The hot gases used for heating the SCM raw materials may be provided in any
15 appropriate way. Thus, the hot gases may be provided by means of a separate heat generator or similar. However, as the SCM production as suggested is combined with cement clinker production it may be advantageous in terms of energy efficiency to extract and use hot gases from cement clinker production for heating of the SCM raw materials. Such hot gases from the cement clinker
20 production may be extracted anywhere where the gases have the required temperature to ensure proper heat treatment of the SCM raw materials. However, to avoid too much uncalcined cement raw materials, being nonreactive in the finished cement product, to end up in the SCM product, it is preferred to use hot gases extracted from the cement clinker cooler. The hot gases may generally be
25 extracted anywhere from the cement clinker cooler where it in view of an overall energy efficiency evaluation of the combined production process suits best. In a traditional cement clinker cooler the hot cement clinker received from the kiln is supported on grate bottom and is moved from one end of said supporting bottom to the other while being cooled by atmospheric air being blown through the
30 supporting bottom and thus the cement clinker. Thus, the temperature in the cement clinker cooler is high in one end and gradually falling in direction of the other end where the cooled cement clinker is discharged. It is preferred to extract the hot gases to be used for the heat treatment of SCM raw materials at or close

to the high temperature end of the cement clinker cooler, thus the enthalpy present in the gases for heating the SCM raw materials is as high as possible. If necessary the hot gases to be used for the heat treatment of SCM raw materials may be further heated before used for heating the SCM raw materials.

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Before the SCM raw materials being subjected to heat exchange with the hot gases they should preferably be pretreated in a separate step to an appropriate dryness and fineness. This may e.g. be done in a drier crusher installation. Another kind of pre-treatment is granulation of fine-grained materials to agglomerates. In addition, the SCM materials may advantageously be subjected to a certain preheating before being subjected to heat exchange with the hot gases. The degree of preheating that is allowed is dependent on the content of various substances in the SCM raw material. Such preheating may be done in a number of preheater cyclones, which may improve the thermal energy efficiency, however, at the same time increase the pressure drop and thus the energy consumption for drawing the gases through the cyclones.

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The heat treated SCM raw materials are after being separated from the hot gases cooled in suitable cooling means.

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The plant for carrying out the method according to the invention for simultaneous production of separate flows of cement clinker and supplementary cementitious material (SCM), respectively, comprises a preheater, a calciner, a kiln and a clinker cooler for preheating, calcining, burning, and cooling cement raw materials, and a separate heat treatment unit for heating SCM raw materials to a temperature of at least 500 °C subject to heat exchange with hot gases and a separator for subsequent separation of the heated SCM raw materials from the hot gases, and being characterized in that it comprises means for directing the hot gases separated from the heated SCM raw materials into the calciner.

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Further characteristics of the plant according to the invention will appear from the following description and the claims.

The invention will now be described in further details with reference to the drawing, being diagrammatical, and where

Fig. 1 shows a general flow diagram of the simultaneous production of separate flows of cement clinker and SCM, respectively, according to the invention for different cement kiln systems,

Fig. 2 shows a plant for simultaneous production of separate flows of cement clinker and SCM, respectively, comprising a SLC cement kiln system,

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Fig. 3 shows a section of an alternative plant of the one shown in Fig. 2, and

Fig. 4 shows a plant for simultaneous production of separate flows of cement clinker and SCM, respectively, comprising an ILC cement kiln system.

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In Fig. 1 is shown a general flow diagram of the simultaneous production of separate flows of cement clinker and SCM, respectively, according to the invention for different cement kiln systems. Basically, two different cement kiln systems comprising a calciner are known, viz. the separate line calciner (SLC) system, where the kiln gases are not directed through the calciner, and the in-line calciner (ILC) system, where the kiln gases are directed through the calciner. Further, in some plants a kiln riser pipe that directs exhaust gases from the kiln to a preheater system may be operated as a calciner, where the air for the combustion is coming through the kiln. The plant shown in Fig. 1 comprises in generally terms a cement clinker production line 1 and a SCM production line 3. The cement clinker production line comprises a preheater 5 for preheating cement raw materials introduced via a feed inlet F, a calciner 7 for calcining preheated cement raw materials, a kiln 9 for burning preheated or calcined raw materials into cement clinker and a clinker cooler 11 for cooling the cement clinker., whereas the SCM production line 3 comprises pre-treatment equipment 13 for pre-treating SCM raw materials in terms of dryness, fineness and/or temperature, a reactor 15 for heating SCM raw materials to a temperature of at least 500 °C subject to heat exchange with hot gases, said reactor 15 being

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connected to separating means for subsequently separating the heated SCM raw materials from the hot gases, and a SCM cooler 17 for cooling the heat treated SCM raw materials. Gases are drawn through the plant by means of a fan 2. Further, a burner station or a heat generator 21 may be provided as an additional
5 heat source for the reactor 15. In the figure the material and gas flows are shown by closed and open arrows, respectively, and it is evident to the skilled person that not all arrows necessary needs to apply and that some boxes may be doubled in some plant configurations. The SCM raw material flow is shown by dotted line.

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In order to eliminate or at least reduce from the production of SCM the emission of gaseous species that are harmful to the environment, it is suggested according to the invention that the hot gases separated from the heated SCM raw materials are directed into the calciner 7 via a duct 16. Hereby these harmful species are
15 effectively immobilised and/or destroyed in the calciner 7.

In Fig. 2 is shown an example of a plant for the simultaneous production of separate flows of cement clinker and SCM, where the cement clinker production line 1 is constituted of a per se known two-stringed SLC kiln system having a kiln
20 line 1a and a calciner line 1b, both comprising a multistage cyclone preheater 5 and a fan 2. The kiln line 1a further comprises a rotary kiln 9 and a riser duct 10, whereas the calciner line 1b comprises a calciner 7. During operation fresh cement raw materials are fed into the two cyclone preheaters 5 via F and are preheated while moving down through the preheaters 5 counter-current to hot
25 gases arriving from the rotary kiln 9 and calciner 7, respectively. Preheated cement raw material from the kiln line 1a is fed into the calciner 7 and thus mixed with cement raw materials preheated in the calciner line 1b. The calcined cement raw material is separated from the calciner exhaust gases in a calciner cyclone 7a and directed to the rotary kiln 9. Some of the cement raw materials preheated
30 in the kiln line 1a may be directed to the rotary kiln 9 without having been calcined. The SCM production line 3 comprises pre-treatment equipment 13 for pre-treating SCM raw materials in terms of dryness, fineness and/or temperature, a gas suspension reactor 15 for heating SCM raw materials entered into said

reactor 15 from the pre-treatment equipment 13 subject to heat exchange with hot gases, a separation cyclone 15a for separating the heated SCM raw materials from the hot gases and a SCM cooler 17 for cooling the heat treated SCM raw materials. According to the invention the hot gases separated from the heated SCM raw materials in separation cyclone 15a are directed into the calciner 7 via duct 16, where the harmful species, as previously mentioned are effectively immobilised and/or destroyed.

In the embodiment shown in Fig. 2, the hot gases used for heating the SCM raw materials in the reactor 15 are extracted from the cement clinker cooler 11, however the hot gases may, as mentioned, be provided in any other appropriate manner, such by the use of a heat generator. By using hot gases from the cement clinker cooler 11, the SCM product may contain a certain amount of clinker dust, which has been entrained with the gases. However, this will not constitute a serious problem, as the SCM product anyway at a later stage is intended for being mixed with cement clinker. Further, a certain amount of the SCM product produced in the reactor 15 may be lost by the separation cyclone 15a and be conveyed to the calciner 7, where it will disturb the chemistry of the calcined raw meal and hence that of the cement clinker. However, this problem may be solved by adjusting the cement raw material mix being fed into the cement kiln system 1. Further, a dividing gate 18 beneath the separation cyclone 15a may be used for controlling the amount of SCM arriving into the calciner 7.

In Fig. 3 is shown an alternative embodiment of the plant shown in Fig. 2. In this embodiment only a proportion of the hot gases extracted from the cement clinker cooler 11 is led through the SCM reactor 15, and in addition fuel is added to the SCM reactor 15 by means of a burner station 21. Hereby, the SCM reactor 15 can be made much smaller, hence getting higher ratio of solids flow to gas flow, thus allowing the separation cyclone 15a to work with a wider range of solids, even fine grained powders. The remaining proportion of the hot gases extracted from the cement clinker cooler 11 that does not pass the SCM reactor 15 could preferably be extracted from the cement clinker cooler 11 through a separate duct. The two proportions of the hot gases extracted from the cement clinker

cooler 11 may subsequently be mixed and directed to the calciner 7 via duct system 16. In this embodiment the SCM reactor 15 may be operated with a moderate or low % O₂ at the exit, which could be useful for controlling the colour of the SCM product.

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In a not shown embodiment, the SCM reactor 15 need not be a gas suspension reactor, as the one shown. It might as well be a hot disc, as the one marketed by FLSmidth A/S and comprising an essentially circular housing with a bottom made up by a rotating disc, where material to be heated and hot gases are introduced
10 via an inlet and following a circular path to an outlet. With such kind of reactor it would be possible to provide a longer treatment, maybe up to one hour, of the SCM materials. Using such a reactor 15 the material should preferably be pre-granulated to agglomerates of uniform size and the agglomerates should preferably contain a combustible substance that can evaporate and burn right
15 above the material bed supported by the rotating disc. The SCM hot disc can be supplied with hot gases from the cement clinker cooler, either with the entire flow passing through, or in a loop duct with only a fraction of the gases going through.

In Fig. 4 is shown an example of a plant for the simultaneous production of
20 separate flows of cement clinker and SCM, where the cement line 1 is constituted of a per se known ILC kiln system, where cement raw materials are introduced via F, preheated in a multistage cyclone preheater 5 subject to heat exchange with hot exhaust gases, calcined in a calciner 7 under supplement of hot gases and fuel, burned into cement clinker in a rotary kiln 9 and cooled in a
25 cement clinker cooler 11. The SCM line 3 comprises as in previous embodiments pre-treatment equipment 13 for pre-treating SCM raw materials in terms of dryness, fineness and/or temperature, a gas suspension reactor 15 for heating SCM raw materials entered into said reactor 15 from the pre-treatment equipment 13 subject to heat exchange with hot gases, a separation cyclone 15a
30 for separating the heated SCM raw materials from the hot gases and a SCM cooler 17 for cooling the heat treated SCM raw materials. According to the invention the hot gases separated from the heated SCM raw materials in separation cyclone 15a are directed into the calciner 7 via duct 16, where the

harmful species, as previously mentioned are effectively immobilised and/or destroyed. In the shown embodiment, the reactor 15 is of the down-draught type and the hot gases separated from the heated SCM raw materials are directed into the calciner 7 via a pyrolysis or incineration chamber 20, which may be
5 designed as a hot disc, as explained previously.

Patent claims

1. A method for simultaneous production of separate flows of cement clinker and supplementary cementitious material (SCM), respectively, where cement raw materials are preheated in a preheater (5), calcined in a calciner (7), burned into cement clinker in a kiln (9) and cooled in a clinker cooler (11), and where SCM raw materials are heated to a temperature of at least 500 °C subject to heat exchange with hot gases and subsequently separated from the hot gases, **characterized in** that the hot gases separated from the heated SCM raw materials are directed into the calciner (7).
2. A method according to claim 1, **characterized in** that the SCM raw materials are heated to the required temperature by heat exchange with hot gases in co-current mode, where the hot gases and the materials to be heated flow in same direction.
3. A method according to claim 1, **characterized in** that hot gases for heating the SCM raw materials are provided by means of a separate heat generator (21).
4. A method according to claim 1, **characterized in** that the hot gases for heating the SCM raw materials are provided from the cement clinker production (1).
5. A method according to claim 4, **characterized in** that the hot gases for heating the SCM raw materials are extracted from the cement clinker cooler (11).
6. A method according to claim 5, **characterized in** that the hot gases for heating the SCM raw materials are extracted at or close to the high temperature end of the cement clinker cooler (11)
7. A method according to any of claims 4 to 6, **characterized in** that the hot gases for heating the SCM raw materials are further heated before used for heating the SCM raw materials.

8. A method according to claim 1, **characterized in** that the SCM raw materials before being subjected to heat exchange with the hot gases are pretreated in a separate step to an appropriate dryness and fineness.

9. A method according to claim 1, **characterized in** that the SCM raw materials are granulated before being subjected to heat exchange with the hot gases.

10. A method according to claim 1, **characterized in** that the SCM raw materials are preheated before being subjected to heat exchange with the hot gases.

11. A method according to claim 1, **characterized in** that the heat treated SCM raw materials after being separated from the hot gases are cooled in suitable cooling means (17).

12. A plant for carrying out the method according to claim 1 for simultaneous production of separate flows of cement clinker and supplementary cementitious material (SCM), respectively, said plant comprises a preheater (5), a calciner (7), a kiln (9) and a clinker cooler (11) for preheating, calcining, burning, and cooling cement raw materials, and a separate heat treatment unit (15) for heating SCM raw materials to a temperature of at least 500 °C subject to heat exchange with hot gases and a separator (15a) for subsequent separation of the heated SCM raw materials from the hot gases, **characterized in** that it comprises means (16) for directing the hot gases separated from the heated SCM raw materials into the calciner (7).

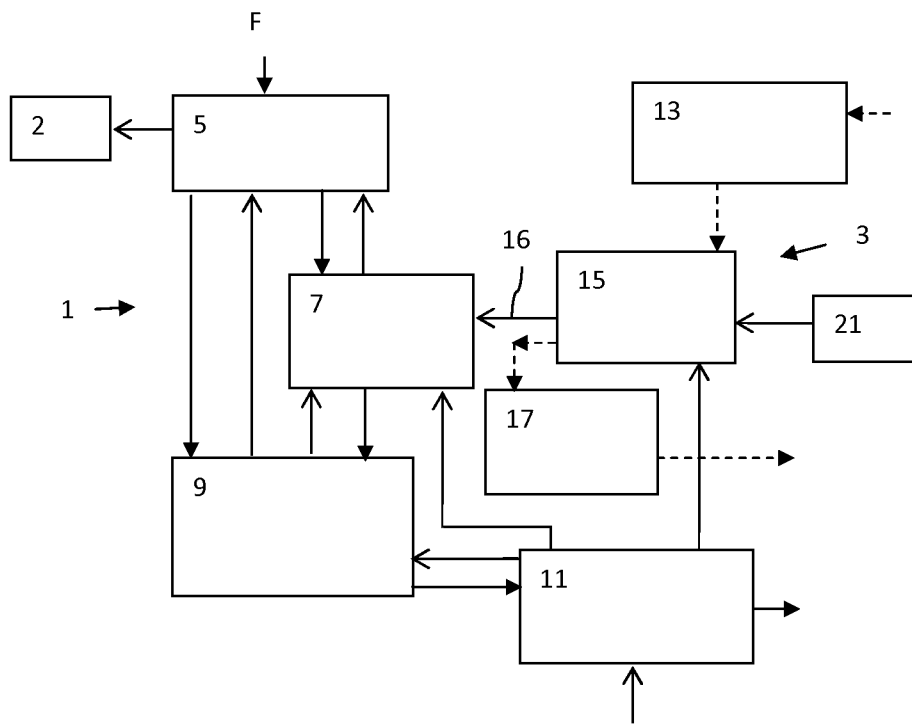


Fig. 1

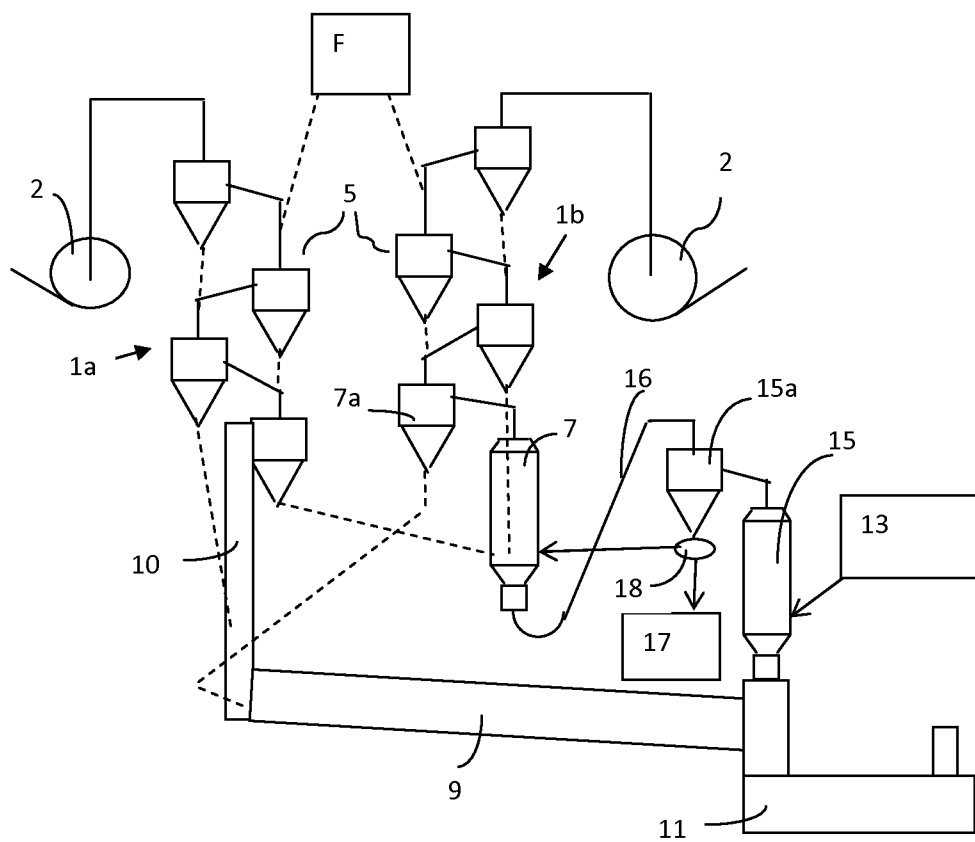


Fig. 2

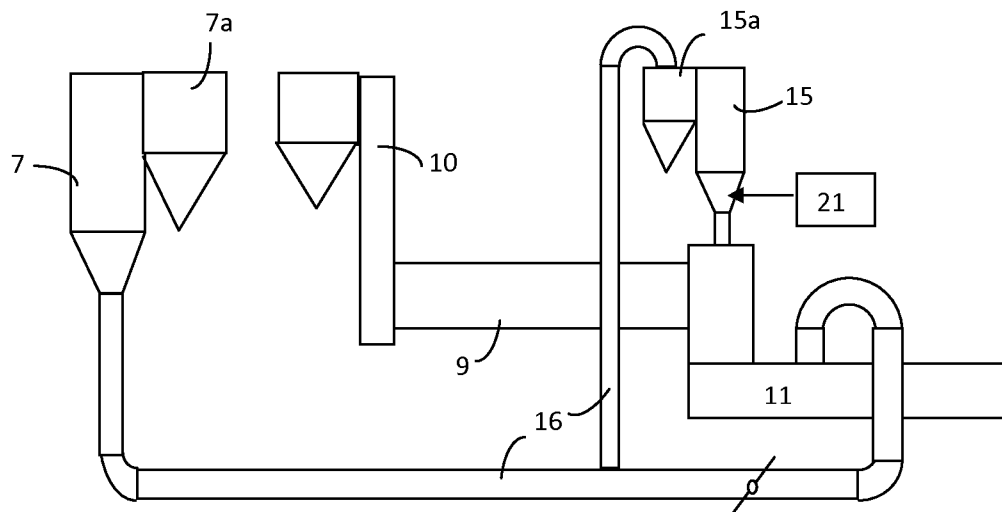


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/053612

A. CLASSIFICATION OF SUBJECT MATTER
INV. F27B7/20
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)
F27B 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 practical, search terms used)

EP0-Internal, PAJ, 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	DE 35 42 004 A1 (KLOECKNER HUMBOLDT DEUTZ AG [DE]; DYCKERHOFF ENG GMBH [DE]) 4 June 1987 (1987-06-04) figure 1 column 4, line 38 - column 6, line 14 -----	1,2,4-12
Y	DE 10 2005 044840 A1 (POLYSIUS AG [DE]) 29 March 2007 (2007-03-29) figure 1 paragraph [0025] - paragraph [0041] ----- -/-	1-12

☒ Further documents are listed in the continuation of Box C.

☒ 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

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
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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.
Y	WEIL S ET AL: "Hydrogen energy from coupled waste gasification and cement production-a thermochemical concept study", INTERNATIONAL JOURNAL OF HYDROGEN ENERGY, ELSEVIER SCIENCE PUBLISHERS B.V., BARKING, GB, vol. 31, no. 12, 1 September 2006 (2006-09-01), pages 1674-1689, XP024899925, ISSN: 0360-3199, DOI: 10.1016/J.IJHYDENE.2005.12.015 [retrieved on 2006-09-01] figure 4 page 1677, paragraph 2.3 -----	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2011/053612

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			EP 1926959 A1 04-06-2008
			US 2008245275 A1 09-10-2008
			WO 2007033749 A1 29-03-2007
