



- (51) **International Patent Classification:**
C22B 1/02 (2006.01) C22B 11/02 (2006.01)
- (21) **International Application Number:**
PCT/FI2010/051022
- (22) **International Filing Date:**
14 December 2010 (14.12.2010)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (71) **Applicant (for all designated States except US):**
OUTOTEC OYJ [FI/FI]; Riihitontuntie 7 E, FI-02200 Espoo (FI).
- (72) **Inventors; and**
- (75) **Inventors/Applicants (for US only):** HOLMSTRÖM, Åke [SE/SE]; Gammelgarn, Svartdal 656, S-623 67 Katthammarsvik (SE). LUNDHOLM, Karin [SE/SE]; Kvistgatan 8, S-931 58 Skellefteå (SE). BERG, Gunnar [SE/SE]; Lillhemsvägen 10, S-93135 Skellefteå (SE). GÜNTNER, Jochen [DE/DE]; Am Sportfeld 4, S-63796 Kahl (DE).
- (74) **Agent:** PAPULA OY; Mechelininkatu 1 a, FI-00180 Helsinki (FI).
- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(54) **Title:** PROCESS AND PLANT FOR TREATING ORE CONCENTRATE PARTICLES CONTAINING VALUABLE METAL

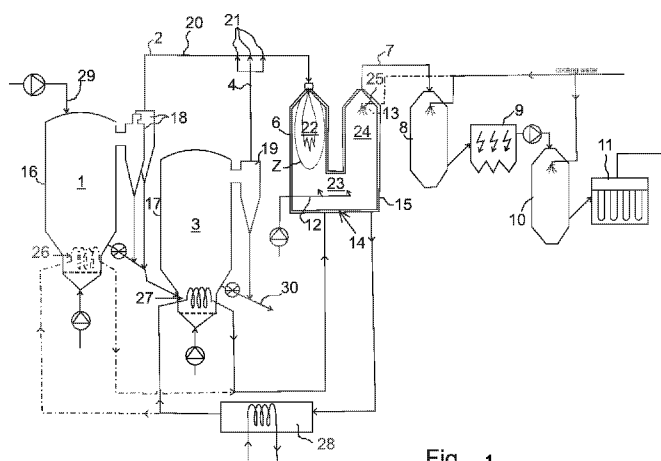


Fig. 1

(57) **Abstract:** The present invention concerns a process and a plant for treating ore concentrate particles containing valuable metal and having at least arsenic and sulfur containing components. The process comprises a two-stage roasting process comprising a first roasting step (1) made in a first roasting reactor (16) and a second roasting step (3) made in a second roasting reactor (17). A gas mixture is formed from the first process gas component (2) obtained from the first roasting step(1)and from the second process gas component (4) obtained from the second roasting step (3). Post combustion of the gas mixture is made in a post combustion chamber (6). The post combustion operates with said reducing and sulphide rich first process gas component (2) and the second process gas component (4) as oxidizer gas in order to decompose SO₃ in the gas mixture to reduce the SO₃ content. The risk of accretion formation and corrosion in the post combustion chamber and in subsequent steps is reduced. Finally the exit gas (7) is exposed to subsequent gas cooling and dust removal steps (8 to 11).



**PROCESS AND PLANT FOR TREATING ORE CONCENTRATE
PARTICLES CONTAINING VALUABLE METAL**

FIELD OF INVENTION

5

The present invention relates to a process in accordance with claim 1. Further, the present invention relates to a plant in accordance with claim 19. More specifically, the invention relates to the off-gas
10 handling and treatment in said process and plant.

BACKGROUND OF INVENTION

Known technique in the art is depicted e.g. in the articles "Roasting developments - especially oxygenated
15 roasting, Developments in Mineral Processing, Volume 15, 2005, Pages 403-432 K.G. Thomas, A.P. Cole", "Roasting of gold ore in the circulating fluidized-bed technology Developments in Mineral Processing, Volume
20 15, 2005, Pages 433-453, J. Hammerschmidt, J. Guntner, B. Kerstiens", and patent documents WO2010/003693, US 6,482,373, AU 650783, US 4,919,715.

Copper and gold concentrates containing arsenic are
25 preferably processed by dearsenifying roasting before further treatment by smelting in a copper plant or cyanide leaching.

The dearsenifying roasting is made by controlling the
30 oxygen potential during arsenic volatilization to maintain iron both as magnetite and pyrrhotite. The calcine is thereafter further processed by conven-

tional matte smelting in case the raw material consists of a copper containing concentrate. Gold rich calcine are often processed by cyanide leaching but the leaching is only efficient, if the calcine is dead
5 roasted or sulphating roasted. A conventional method to treat arsenic rich gold concentrates is therefore a two stage roasting process whereby both stages consist of fluidized beds.

10 The first fluidized bed is the dearsenifying step, operating at a very low oxygen potential, and the second fluidized bed is the dead roasting or sulphating step, operating with an excess of oxygen.

15 The process gas leaving the dearsenifying roasting will contain sulphur rich gas compounds such as elementary sulphur, hydrogen sulphide and arsenic sulphide while the process gas leaving the second oxidizing roasting will contain oxygen and oxidized com-
20 pounds like SO_3 .

The roasting process gas is normally further processed by separation of calcine and process gas in cyclones, post combustion, gas cooling and dust cleaning in
25 electrostatic precipitator and possibly bag filter and finally conversion of SO_2 to sulphuric acid.

Known problems in the further processing are:

30 - The forming of accretions which could fall down and damage equipment or block gas passage. The accretions

are e.g. formed due to local under cooling of the process gas or on cold surfaces in the equipment.

5 - Condensation of arsenic on cold surfaces which will form said accretions.

- Condensation of acid mist on cold surfaces which will cause corrosion and contribute to formation of accretion.

10

- If the acid mist quantity is high, the cost for effluent treatment will also be high.

15 - Heat recovery of the system has often been limited to the production of saturated steam which is less favourable for the production of electric energy.

These problems were solved before in the following ways:

20

The post combustion air can for instance be added at the cyclone exit. However, in some cases the post combustion can cause accretions in gas ducts and this is more likely if the combustion is made with a large amount of air in ambient temperature.

25

The forming of accretions on cold surfaces in the equipment is normally solved by the use of preheated air, which requires separate heating equipment with increased investment cost and operating costs (maintenance and possibly heating fuel). Forming of accretions in the equipment is normally avoided by insulat-

30

ing the equipment well so that no cold surfaces exist, although it is also accepted that accretions will form where the insulation is damaged or not properly done.

5 Gas cooling during two-stage roasting can either be made by direct cooling with water injection in a cooling tower or through indirect cooling through cooling coils in the fluidized beds and by conventional steam boiler. Lead and arsenic contents in the concentrate
10 and SO₃ concentration in process gas influence suitable cooling method, since these elements can cause formation of accretions on cooling surfaces.

Example of compounds that forms accretions are elemental
15 tal lead at cooling coils in the first dearsenifying stage and SO₃ or arsenic trioxide at the boiler tubes of the steam boiler. It is today generally accepted that high SO₃ concentrations cause higher cost in the effluent treatment plant.

20

Corrosion of the equipment is normally avoided by insulating the equipment well so that no or little SO₃ condensation occurs, although it is also accepted that corrosion will occur over time and for example where
25 the insulation is damaged or not properly done. It would be best to be able to avoid high SO₃ concentrations in the process gas. This is today, to some extent, done by controlling the process with modern control systems. Further reductions would be an advantage.
30 tage.

Heat recovery in form of steam is today done by steam generation coils in the fluidised bed itself often without any superheating. A normal steam boiler is sometimes used in the process gas stream, but with similar risks of accretions forming and corrosion as described.

OBJECT OF INVENTION

10 The object of the invention is to eliminate the above mentioned drawbacks.

A particular object of the invention is to provide a process and plant wherein the risk of corrosion and forming of accretions are reduced during post combustion and down-stream in the gas cleaning system. Further, an object of the invention is to provide a process and plant wherein SO_3 concentration in the process gas can be reduced and the risk of corrosion damages by SO_3 is reduced. Further, an object of the invention is to provide a process and plant wherein the effluent handling costs are reduced. Further, an object of the invention is to reduce the total process gas volume which saves both investment cost and operating costs

25

SUMMARY OF INVENTION

The process according to the invention is characterized by what is set forth in claim 1. Further, the plant according to the invention is characterized by what is set forth in claim 19.

30

The invention concerns a process for treating ore concentrate particles containing valuable metal and having at least arsenic and sulfur containing components. The process comprises roasting the concentrate particles in a first roasting step operating with a low oxygen potential for dearsenifying the concentrate. The off-gas leaving the first roasting step is treated to separate calcine and a sulphide rich first process gas component. Further, the process comprises roasting the calcine led from the first roasting step in a second roasting step operating with an excess of oxygen. The off-gas leaving the second roasting step is treated to separate calcine and a second process gas component. Further the process comprises post combustion of the process gas component and treating the process gas in subsequent gas cooling and dust removal steps.

In accordance with the invention the process further comprises forming of a gas mixture of the first process gas component and the second process gas component which is oxygen containing warm oxidizer gas, and post combustion of said gas mixture in a post combustion chamber, said post combustion operating with said reducing and sulphide rich first process gas component and said second gas component as oxidizer, in order to decompose SO_3 in the gas mixture to reduce the SO_3 content in the exit gas exiting post combustion chamber and to reduce the risk of accretion formation and corrosion in the post combustion chamber and in subsequent steps. Finally the process comprises exposing

the exit gas to subsequent gas cooling and dust removal steps.

In an embodiment of the process additional post combustion air is inserted into the post combustion chamber after main post combustion reaction zone to avoid SO₃ formation.

In an embodiment of the process residence time of the gas in the post combustion chamber is arranged to be long enough to ensure complete combustion of all easily oxidized compounds, such as hydrogen sulphide, elemental sulphide, arsenic sulphide, elemental arsenic, present in the gas mixture.

15

In an embodiment of the process the long enough residence time is provided by arranging a sufficient volume of the post combustion chamber.

In an embodiment of the process the process comprises a step of controlling the temperature in the post combustion chamber.

In an embodiment of the process the step of controlling the temperature in the post combustion chamber includes direct injection of cooling water into the post combustion chamber.

In an embodiment of the process the step of controlling the temperature in the post combustion chamber includes indirect cooling of the walls of the post combustion chamber with steam to keep the temperature

30

of the walls of the post combustion chamber above the condensation temperature of As_2O_3 or SO_3 .

In an embodiment of the process said indirect cooling
5 is implemented by a radiation cooler formed by a double shell structure of the walls of the post combustion chamber the steam flowing within the double shell structure of the wall whereby hot gas within the chamber by radiation converts saturated steam to super-
10 heated steam.

In an embodiment of the process heat is recovered from the superheated steam for internal or external use of energy.

15

In an embodiment of the process the first roasting step is implemented in a first fluidized bed reactor and the second roasting step is implemented in a second fluidized bed reactor.

20

In an embodiment of the process the process includes extracting heat from the fluidized bed of the first fluidized bed reactor.

25 In an embodiment of the process the process includes extracting heat from the fluidized bed of the second fluidized bed reactor.

In an embodiment of the process the off-gas leaving
30 the first roasting step is separated by at least one first cyclone separator.

In an embodiment of the process the off-gas leaving the second roasting step is separated by at least one second cyclone separator.

5 In an embodiment of the process the second process gas component which is mixed with the first process gas component, is hot, preferably the temperature of the second process gas component is about 650 ... 700°C, to ensure fast reaction with the first process gas compo-
10 nent.

In an embodiment of the process the additional combustion air is preheated to at least 200°C, preferably by the heat extracted from air cooled conveyors or calcine coolers.
15

In an embodiment of the process the calcine is completely roasted in the second roasting step.

20 In an embodiment of the process the valuable metal is any of platinum-group metals, gold, silver, copper or zinc.

The invention also concerns a plant for treating ore concentrate particles containing valuable metal and having at least arsenic and sulfur containing components. The plant comprises a first roasting reactor operating with a low oxygen potential for dearsenifying the concentrate and a first separator arranged to
25 receive off-gas from the first roasting reactor and to separate from said off-gas calcine and a sulphide rich first process gas component. Further, the plant com-
30

prises a second roasting reactor arranged to receive calcine from the first roasting reactor and from the first separator, said second roasting reactor operating with an excess of oxygen, and a second separator
5 arranged to receive off-gas from the second roasting reactor and to separate from said off-gas calcine and a second process gas component. Moreover, the plant comprises means for post combustion of the process gas component and gas cooling and dust removal equipment
10 for further treating the process gas.

In accordance with the invention the plant further comprises means for forming a gas mixture of the first process gas component and the second process gas component which is oxygen containing warm oxidizer gas.
15 Said means for post combustion includes a post combustion chamber for post combustion of said gas mixture, said post combustion chamber operating with said reducing and sulphide rich first process gas component and said second process gas component as oxidizer, in
20 order to decompose SO_3 in the gas mixture to reduce the SO_3 content in the exit gas exiting post combustion chamber and to reduce the risk of accretion formation and corrosion in the post combustion chamber and in
25 subsequent gas cooling and dust removal equipment.

In an embodiment of the plant the plant comprises a first pipeline for guiding the first process gas component from the first separator to the post combustion
30 chamber, and that the means for forming the gas mixture comprises a plurality of connections at several positions along the first pipeline for introducing the

second process gas component via said connections into the stream of the first process gas component.

5 In an embodiment of the plant the post combustion chamber comprises a first chamber part forming a reaction chamber to which the gas mixture is fed; a second chamber part comprising means for inserting additional combustion air; and a third chamber part from which the gas exits from the post combustion chamber.

10

In an embodiment of the plant the post combustion chamber comprises cooling means for controlling the temperature in the chamber.

15 In an embodiment of the plant the cooling means comprises a water spraying nozzle for injecting cooling water into the post combustion chamber for direct cooling.

20 In an embodiment of the plant the cooling means comprises a radiation cooler formed by a double shell structure of the walls of the post combustion chamber for indirect cooling of the walls of the post combustion chamber with steam streaming between the shells.

25

In an embodiment of the plant the plant comprises a first heat exchanger for extracting heat from the fluidized bed of the first fluidized bed reactor.

30 In an embodiment of the plant the plant comprises a second heat exchanger for extracting heat from the fluidized bed of the second fluidized bed reactor.

In an embodiment of the plant the plant comprises a third heat exchanger for recovering heat from the superheated steam generated by the radiation cooler
5 for internal or external use of energy.

The advantage of the invention is that it solves accretion problems during post combustion and downstream in the gas cleaning system as well as gas cooling during post combustion. The risk for corrosion damages caused by SO_3 is also reduced. The suggested mixing of the process gases reduces the amount of SO_3 , thus reducing corrosion risks and costs for effluent treatment. The suggested mixing of the process gases
15 gives a cost-free pre-heated post combustion gas (oxygen containing). Only a minor part needs, possibly, to be heated in another way. The pre-heating gives no forming of accretions neither in the post combustion chamber nor in the following equipment without the need for extra, costly, pre-heating equipment. The suggested post combustion unit makes it possible to insert steam-superheating coils after the post combustion unit without the risk for forming of accretions or corrosion by SO_3 . The system can superheat steam
20 without the need of external steam superheating (separately fired superheater). The production of steam and superheating is well balanced to the need for process gas cooling, this will avoid a costly and complicated control systems (as needed for an external superheater).
25
30

LIST OF DRAWINGS

The accompanying drawing, which is included to provide a further understanding of the invention and constitutes a part of this specification, illustrates an embodiment of the invention and together with the description helps to explain the principles of the invention.

10 Figure is a schematic flow sheet of one embodiment of a process and plant according to the invention.

DETAILED DESCRIPTION OF INVENTION

15 The flow sheet in Figure shows a two stage roasting plant with its off-gas handling system. This process layout is suitable when the raw material is an arsenic contaminated sulfide ore concentrate which valuable particles contain precious metals like gold and silver. Copper and zinc can also be present in large or 20 small quantities. The concentrate is fed at the inlet 29 to the first roasting step 1 which is implemented in a first roasting reactor 16. The first roasting reactor 16 is a first fluidized bed reactor. The first 25 roasting step 1 is a dearsenifying step operating at a very low oxygen potential. A first cyclone separator 18 is arranged to receive process gas with a lot of calcine from the first roasting reactor 16 and to separate from said process gas the calcine and a sulphide rich first process gas component 2 with less calcine. 30 The calcine contains the valuable metals and has a low content of arsenic. The first process gas component 2

leaving the dearsenifying roasting contains sulphur rich gas compounds such as elementary sulphur, hydrogen sulphide and arsenic sulphide.

5 A second roasting reactor 17 is arranged to receive calcine from the first roasting reactor 16 and from the first separator 18. The second roasting step 3 is made in a second roasting reactor 17 which is the second fluidized bed reactor wherein the calcine is completely roasted, ie. dead roasted or sulfating
10 roasted, and it operates with an excess of oxygen. The meaning of dead roasted or sulfating roasted material is that all sulfide sulfur has been removed and any remaining sulfur consists of sulfates. A second cyclone separator 19 is arranged to receive process gas
15 from the second roasting reactor 17 and to separate from said process gas calcine and a second process gas component 4. The second process gas component 4 leaving the second oxidizing roasting will contain oxygen
20 and oxidized compounds like SO₃.

The calcine from the second roasting reactor 17 and from the second cyclone separator 19 is fed via outlet 30 to further processing of the calcine, cooling,
25 leaching etc. (not shown in Figure).

The plant and the process further comprises means for forming a gas mixture of the first process gas component 2 and the second process gas component 4 which is
30 oxygen containing warm oxidizer process gas.

The means for forming a gas mixture may be arranged so that a plurality of connections 21 is arranged at several positions along the first pipeline 20 which leads the first process gas component 2 from the first separator 18 to the post combustion chamber 6. The second process gas component 4 may be introduced via said plurality of connections 21 into the stream of the first process gas component 2. This improves mixing and reduces combustion time.

10

The second process gas component 4 is hot, typically 650 - 700 °C, which ensures a fast reaction with the roaster gas. When warm additional post combustion air 12 is used, air cooled conveyors (not shown in Figure) or calcine coolers (not shown in Figure) could be used as air preheaters to preheat the air to approximately 200 °C.

15

Post combustion of the gas mixture is implemented in a post combustion chamber 6. The post combustion chamber 6 operates with said reducing and sulphide rich first process gas component 2 and said second process gas component 4 and, if needed, with warm air 12. Conditions during post combustion, e.g. an increased gas temperature and presence of reducing gas components, will make it possible to decompose SO_3 and thus reduce the SO_3 content in process gas at the post combustion exit 7. This is an important feature since it will reduce the risk of acid condensation and the subsequent formation of sticky dust, especially in the conditioning tower 10 and bag filter 11 that operate close to or below the SO_3 dew point.

25

30

The post combustion chamber 6 comprises a first chamber part 22 forming a reaction chamber to which the gas mixture is fed. Further the post combustion chamber comprises a second chamber part 23 having means for inserting additional combustion air 12. Additional post combustion air 12 is inserted into the post combustion chamber 6 after main post combustion reaction zone Z to avoid SO₃ formation. The gas exits from the post combustion chamber 6 via a third chamber part 24. The exit gas 7 exiting the post combustion chamber 6 is led to conventional gas cooling and dust removal steps 8 to 11, which may include leading the exit gas 7 via a cooling tower 8 to an electrostatic precipitator 9 and then to a bag filter 11.

The post combustion chamber 6 must have such a volume that the residence time is long enough to ensure complete combustion of all easily oxidized compounds present in the gas mixture, e.g. hydrogen sulphide, elemental sulphide, arsenic sulphide and elemental arsenic.

The reaction temperature during post combustion is increased due to exothermic reactions but must be controlled to avoid over-heating since that should cause formation of partially melted and sticky material in the post combustion chamber 6.

The temperature control of post combustion is either made by direct injection of cooling water via a water spraying nozzle 25 into the post combustion chamber 6

or by indirect cooling of walls 15 of the post combustion chamber 6 by means of steam superheating or by a combination of both.

5 Direct injection of cooling water is used when no energy recovery is included in the roaster flow sheet while indirect steam cooling is used when energy recovery 28 is included.

10 Direct water injection in combination with indirect cooling steam cooling can be necessary to control the flame temperature during combustion to avoid formation of sticky material. The indirect steam cooling in the post combustion walls 15 will serve three purposes,
15 the walls will be warm enough so that no accretions will form or corrosion occur, and the walls will be cold enough to avoid overheating of both the walls and the post combustion gas and at the same time produce superheated steam.

20

The indirect cooling means comprises a radiation cooler 14 formed by a double shell structure of the walls 15 of the post combustion chamber 6 for indirect cooling of the walls of the post combustion chamber with steam streaming between the shells. The walls 15 may
25 be made of cooling panels that by radiation from the hot gas inside the chamber 6 converts saturated steam within the walls 15 to superheated steam. By using steam can be ensured that the wall temperature of the
30 post combustion chamber 6 doesn't drop to levels where condensation could form at the walls.

It is also possible to have indirect steam cooling, partly or only, by inserting superheating coils into the gas stream in the third part 24 of the post combustion chamber 6 or in the following gas duct. As the SO₃ concentration is reduced, any metallic lead vapour in the roaster gas has been oxidized to non-condensing lead compounds like PbO and the process gas has a temperature that is controlled at a level giving no or little sticky materials in the post combustion chamber. Correct insulation of the post combustion chamber would then be needed.

If lead free concentrates are treated, a first heat exchanger 26 may be provided to extract heat from the fluidized bed of the first fluidized bed reactor 16 (steam circuit shown with dot-and-dash line in Figure), and a second heat exchanger 27 for extracting heat from the fluidized bed of the second fluidized bed reactor 17 (steam circuit shown with a solid line in Figure). The heat exchangers 26 and 27 may be steam coils 26, 27 with the same superheating possibilities as described above.

If lead containing concentrates are roasted, only the second fluidized bed reactor 17 can be provided with the steam coil 27, because lead vapour would condense on the steam coil 26 in the first reactor 16 which would cause accretions and harm the roasting operation. In that case heat is extracted only from the fluidized bed of the second fluidized bed reactor 17.

Preferably the superheated steam generated by the radiation cooler 14 is led via a third heat exchanger 28 for recovering heat from the superheated steam for internal use in the process itself, e.g. steam heating of leaching tanks, and/or external use of energy. The external use may include e.g. production of electric energy by a turbine.

It is obvious to a person skilled in the art that with the advancement of technology, the basic idea of the invention may be implemented in various ways. For example, although a two-stage roasting process has been described, it should be understood that the process may include more than two, e.g. three or more, roasting stages, and, respectively, the plant may include more than two, e.g. three or more, roasting reactors. The invention and its embodiments are thus not limited to the examples described above, instead they may vary within the scope of the claims.

CLAIMS

1. A process for treating ore concentrate particles containing valuable metal and having at least arsenic and sulfur containing components, which process comprises:

- roasting the concentrate particles in a first roasting step (1) operating with a low oxygen potential for dearsenifying the concentrate,

10 - the off-gas leaving the first roasting step (1) is treated to separate calcine and a sulphide rich first process gas component (2),

- roasting the calcine led from the first roasting step in a second roasting step (3) operating with an excess of oxygen,

15 - the off-gas leaving the second roasting step is treated to separate calcine and a second process gas component (4),

- post combustion of the process gas component (2, 4), and

20 - treating the process gas in subsequent gas cooling and dust removal steps,

characterized in that

the process further comprises

25 - forming a gas mixture of the first process gas component (2) and the second process gas component (4) which is oxygen containing warm oxidizer gas, and

- post combustion of said gas mixture in a post combustion chamber (6), said post combustion operating with said reducing and sulphide rich first process gas component (2) and said second process gas component (4) as oxidizer gas, in order to decompose

30

SO₃ in the gas mixture to reduce the SO₃ content in the exit gas (7) exiting the post combustion chamber and to reduce the risk of accretion formation and corrosion in the post combustion chamber and in subsequent steps, and

- exposing the exit gas (7) to subsequent gas cooling and dust removal steps (8 to 11).

2. The process according to claim, **characterized in that** additional post combustion air (12) is inserted into the post combustion chamber (6) after main post combustion reaction zone (Z) to avoid SO₃ formation.

3. The process according to claim 1 or 2, **characterized in that** the residence time of the gas in the post combustion chamber (6) is arranged to be long enough to ensure complete combustion of all easily oxidized compounds, such as hydrogen sulphide, elemental sulphide, arsenic sulphide, elemental arsenic, present in the gas mixture.

4. The process according to claim 3, **characterized in that** the long enough residence time is provided by arranging a sufficient volume of the post combustion chamber (6).

5. The process according to any one of the claims 1 to 4, **characterized in that** the process comprises a step of controlling the temperature in the post combustion chamber.

6. The process according to claim 5, **characterized in that** the step of controlling the temperature in the post combustion chamber (6) includes direct injection of cooling water (13) into the post combustion chamber (6).

7. The process according to claim 5 or 6, **characterized in that** the step of controlling the temperature in the post combustion chamber (6) includes indirect cooling of the walls of the post combustion chamber with steam to keep the temperature of the walls of the post combustion chamber above the condensation temperature of As_2O_3 or SO_3 .

8. The process according to claim 7, **characterized in that** said indirect cooling is implemented by a radiation cooler (14) formed by a double shell structure of the walls (15) of the post combustion chamber (6) the steam flowing within the double shell structure of the wall whereby hot gas within the chamber (6) by radiation converts saturated steam to superheated steam.

9. The process according to claim 8, **characterized in that** heat is recovered from the superheated steam for internal or external use of energy.

10. The process according to any one of the claims 1 to 9, **characterized in that** the first roasting step (1) is implemented in a first fluidized bed reactor (16) and the second roasting step is implemented in a second fluidized bed reactor (17).

11. The process according to claim 10, **characterized in that** the process includes extracting heat from the fluidized bed of the first fluidized bed reactor (16).
- 5 12. The process according to claim 10 or 11, **characterized in that** the process includes extracting heat from the fluidized bed of the second fluidized bed reactor (17).
- 10 13. The process according to any one of the claims 1 to 12, **characterized in that** the off-gas leaving the first roasting step (1) is separated by at least one first cyclone separator (18).
- 15 14. The process according to any one of the claims 1 to 13, **characterized in that** the off-gas leaving the second roasting step (3) is separated by at least one second cyclone separator (19).
- 20 15. The process according any one of the claims 1 to 14, **characterized in that** the second process gas component (4) which is mixed with the first process gas component (2) is hot, preferably the temperature of the second process gas component (4) is about 650 ...
25 700°C, to ensure fast reaction with the first process gas component (2).
16. The process according any one of the claims 2 to 15, **characterized in that** the additiona post combustion air (12) is preheated to at least 200°C, preferably by the air cooled conveyors or calcine coolers.
- 30

17. The process according any one of the claims 1 to 16, **characterized in that** in a second roasting step (3) the calcine is completely roasted.

5 18. The process according any one of the claims 1 to 17, **characterized in that** the valuable metal is any of platinum-group metals, gold, silver, copper or zinc.

19. A plant for treating ore concentrate particles
10 containing valuable metal and having at least arsenic and sulfur containing components, which plant comprises:

- a first roasting reactor (16) operating with a low oxygen potential for dearsenifying the concentrate,
15

- a first separator (18) arranged to receive off-gas from the first roasting reactor and to separate from said off-gas calcine and a sulphide rich first process gas component (2),

20 - a second roasting reactor (17) arranged to receive calcine from the first roasting reactor (16) and from the first separator (18), said second roasting reactor operating with an excess of oxygen,

- a second separator (19) arranged to receive
25 off-gas from the second roasting reactor and to separate from said off-gas calcine and a second process gas component (4),

- means for post combustion of the process gas component (2, 4), and

30 - gas cooling and dust removal equipment (8 to 11) for further treating the process gas,

characterized in that the plant further comprises means for forming a gas mixture of the first process gas component (2) and the second process gas component (4) which is oxygen containing warm oxidizer gas; and
5 that said means for post combustion includes a post combustion chamber (6) for post combustion of said gas mixture, said post combustion chamber operating with said reducing and sulphide rich first process gas component (2) and said second process gas component (4)
10 as oxidizer in order to decompose SO_3 in the gas mixture to reduce the SO_3 content in the exit gas (7) exiting post combustion chamber and to reduce the risk of accretion formation and corrosion in the post combustion chamber and in subsequent gas cooling and dust
15 removal equipment (8 to 11).

20. The plant according to claim 19, **characterized in that** the plant comprises a first pipeline (20) for guiding the first process gas component (2) from the
20 first separator (18) to the post combustion chamber (6), and that the means for forming the gas mixture comprises a plurality of connections (21) at several positions along the first pipeline (20) for introducing the second process gas component (4) via said connections (21) into the stream of the first process gas
25 component (2).

21. The plant according to claim 19 or 20, **characterized in that** the post combustion chamber (6) comprises
30 a first chamber part (22) forming a reaction chamber to which the gas mixture is fed; a second chamber part (23) comprising means for inserting additional combus-

tion air (12); and a third chamber part (24) from which the gas exits from the post combustion chamber.

22. The plant according to any one of the claims 19 to
5 21, **characterized in that** the post combustion chamber (6) comprises cooling means for controlling the temperature in the chamber.

23. The plant according to claim 22, **characterized in**
10 **that** the cooling means comprises a water spraying nozzle (25) for injecting cooling water (13) into the post combustion chamber for direct cooling.

24. The plant according to claim 22 or 23, **character-**
15 **ized in that** the cooling means comprises a radiation cooler (14) formed by a double shell structure of the walls (15) of the post combustion chamber (6) for indirect cooling of the walls of the post combustion chamber with steam streaming between the shells.

20

25. The plant according to any one of the claims 19 to
24, **characterized in that** the plant comprises a first heat exchanger (26) for extracting heat from the fluidized bed of the first fluidized bed reactor (16).

25

26. The plant according to any one of the claims 19
to 25, **characterized in that** the plant comprises a
second heat exchanger (27) for extracting heat from
the fluidized bed of the second fluidized bed reactor
30 (17).

27. The plant according to any one of the claims 19 to
26, **characterized in that** the plant comprises a third
heat exchanger (28) for recovering heat from the su-
perheated steam generated by the radiation cooler (14)
5 for internal or external use of energy.

1/1

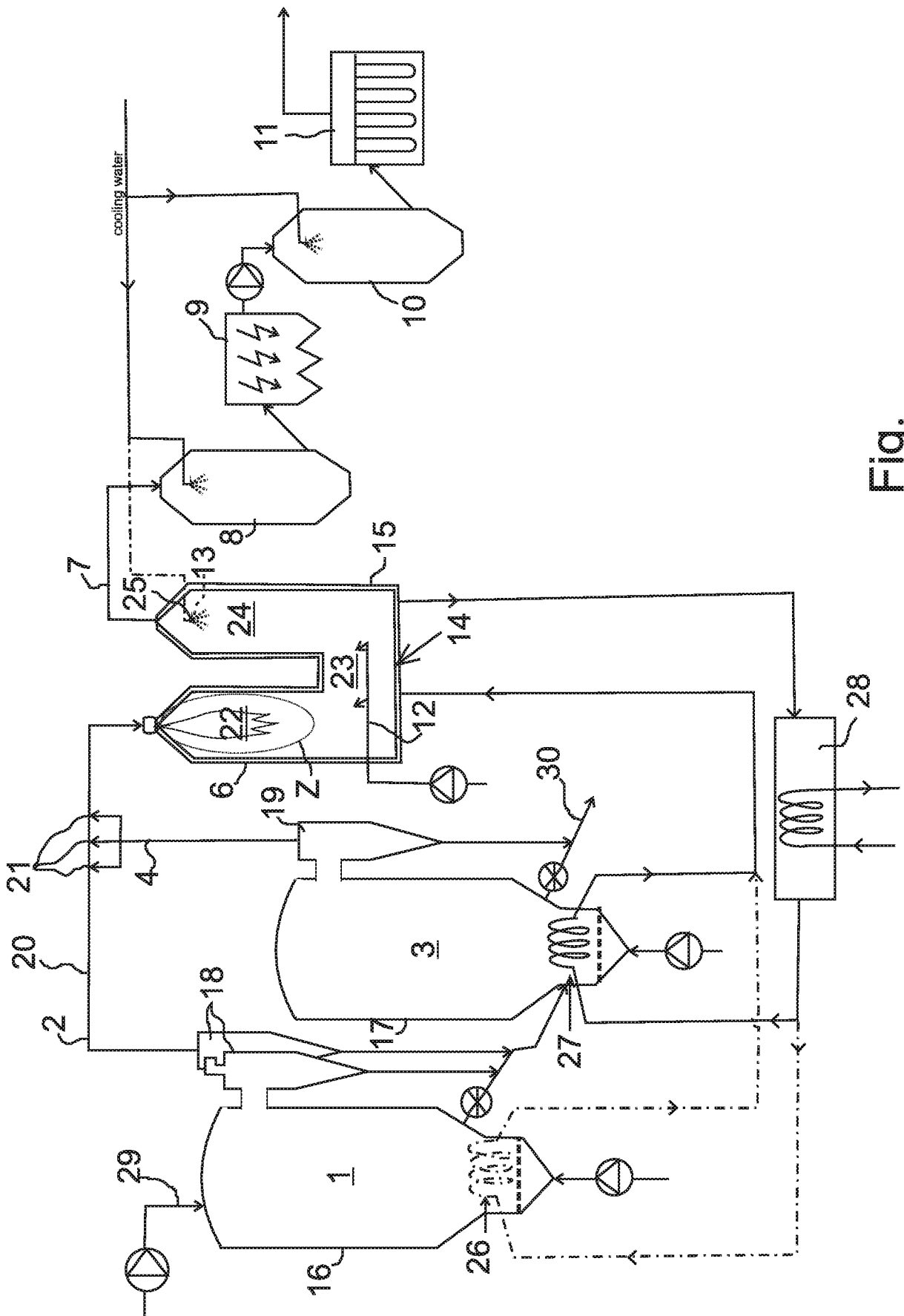


Fig.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2010/051022

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: C22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DKElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI, INSPEC, COMPDX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6482373 B1 (HANNAFORD ANTHONY L et al.) 19 November 2002 (19.11.2002)	1 - 27
A	US 5123956 A (FERNANDEZ RENE R et al.) 23 June 1992 (23.06.1992)	1 - 27
A	US 3791812 A (FRANK R et al.) 12 February 1974 (12.02.1974)	1 - 27

 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

"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

07 September 2011 (07.09.2011)

Date of mailing of the international search report

09 September 2011 (09.09.2011)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland

Facsimile No. +358 9 6939 5328

Authorized officer
Teppo Fält

Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2010/051022

Patent document cited in search report	Publication date	Patent family members(s)	Publication date		
US 6482373 B1	19/11/2002	US 6248301 B1	19/06/2001		
		MX 9201820 A	01/01/1993		
		BR 9201355 A	01/12/1992		
		ZA 9202633 A	11/10/1993		
		RU 2079562 C1	20/05/1997		
		CA 2065837 A1	13/10/1992		
		AU 1482492 A	15/10/1992		
		AU 656952B B2	23/02/1995		
		ES 2117028T T3	01/08/1998		
		EP 0508542 A2	14/10/1992		
		DE 69225993T T2	10/12/1998		
		DE 4122895 C1	03/12/1992		
		DE 4122894 C1	26/11/1992		
		US 5123956 A	23/06/1992		
US 5123956 A	23/06/1992	US 6248301 B1	19/06/2001		
		US 6482373 B1	19/11/2002		
		BR 9201355 A	01/12/1992		
		ZA 9202633 A	11/10/1993		
		RU 2079562 C1	20/05/1997		
		CA 2065837 A1	13/10/1992		
		AU 1482492 A	15/10/1992		
		AU 656952B B2	23/02/1995		
		ES 2117028T T3	01/08/1998		
		EP 0508542 A2	14/10/1992		
		DE 69225993T T2	10/12/1998		
		US 3791812 A	12/02/1974	AU 5007472 A	20/06/1974
				AU 468797B B2	22/01/1976
				CA 966671 A1	29/04/1975

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

C22B 1/02 (2006.01)

C22B 11/02 (2006.01)