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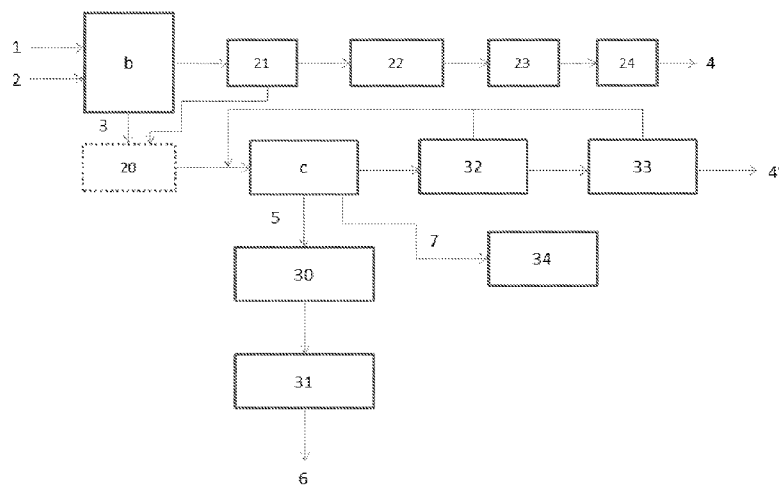
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(54) Title: PROCESS FOR COPPER SMELTING

FIG 1



(57) Abstract: The present invention provides a process for direct-to- blister copper flash smelting, where the energy balance of the smelting process and decreasing the overall impurity content of volatile components in controlled by roasting at least part of the copper concentrate, together with flue dust, before the smelting step. The present invention further provides a use calcine obtained by the roasting step of the process of the invention as a coolant in direct-to- blister flash smelting.

PROCESS FOR COPPER SMELTING

FIELD OF THE INVENTION

The present invention relates to smelting of copper concentrates having low Cu/Fe ratio, in particular chalcopyrite concentrates, and provides a process for copper smelting, where the energy balance of the smelting process is controlled and the overall impurity content of volatile components is decreased by roasting at least part of the copper concentrate before the smelting step, optionally together with flue dust.

BACKGROUND OF THE INVENTION

The concentrates normally used for direct-to-blister copper flash smelting process, have high Cu/Fe ratios and quite low sulfur concentrations compared to chalcopyrite concentrates. These concentrates are however more seldom available compared to chalcopyrite concentrates. The impurity content of the concentrates is increasing and the high copper – low iron concentrates that are very suitable for the direct-to-blister process are becoming scarce. Quite often concentrates with high heat value are encountered.

In conventional flash smelting chalcopyrite concentrates are commonly used as a feed material. Chalcopyrite concentrate has a relatively high heat value compared with other copper concentrates, because of the high sulfur content. In particular chalcopyrite concentrates contain much sulfide, which has a high heat value. This type of concentrate generates too much heat in particularly in direct-to-blister process, where blister copper is formed in one step and thus all the iron is oxidized and also part of the copper is oxidized to copper oxide. Due to these changes in the heat values and impurities of the concentrates methods for controlling the thermal balance of the flash smelting and removal of impurities are needed.

The roasting step in the conventional flash smelting processes is typically carried out in the reaction shaft in temperatures in excess of 1000 °C because in the conventional flash smelting processes roasting and smelting takes place in one step.

In order to maintain the thermal balance of the smelting process it is possible to feed coolants to the smelting stage together with the concentrate. In a conventional method solid coolant materials are fed through the concentrate burner of the flash smelting furnace as described for example in WO 2012059646 A1. Such coolant materials, however, often need to be dried

before feeding. Furthermore, such coolant materials are not always available for a particular smelter or they have to be transported to the smelter site from a different location, which is often very expensive. Another method to maintain the thermal balance is decreasing the oxygen enrichment; this, however, increases the volume of the off gas, which requires larger equipment in the off gas line.

Furthermore, the use of impure concentrates leads to problems with the product anode copper quality. In current practice flue dust produced during flash smelting is either recycled directly back into the furnace or an impurity removal process is used prior to returning the dust to the furnace, for example a hydrometallurgical process. A conventional flash smelting process operates according to the standard autogenous smelting processes, that is, drying and homogenization of concentrate, smelting of sulfide materials, converting, and refining in anode furnace (so-called fire refining). Substances or compounds having high partial pressures are partially removed to gas phase during smelting and converting. However, a substantial proportion of these is ultimately contained in anode copper, which is then usually further refined by electrolysis, in which the presence of impurities such as arsenic (As), antimony (Sb) and bismuth (Bi) cause major problems.

Directly recycling the flue dust will not solve the impurity problem as there is no outlet for the impurities and thus will even cause build-up of impurity concentrations in the process. The dust, however, needs to be recycled due to its high copper content in order to minimize the copper loss in the process. The hydrometallurgical process, however, requires many steps and a rather large space is needed for such kind of plant.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is thus to provide a process, in particular for copper smelting for producing high quality blister and anode copper economically, using as feed material copper concentrate, in particular chalcopyrite concentrate and/or impure concentrate. The process comprises pretreating of at least part of the copper concentrate optionally together with flue dust from the smelting process prior to smelting.

The present invention further provides a use of calcine obtained by pretreatment step of the process of the invention as an (endothermic) coolant indirect-to-blister copper flash smelting. The objects of the invention are

achieved by a process and use characterized by what is stated in the independent claim. The preferred embodiments of the invention are disclosed in the dependent claims.

5 The invention is based on the realization that copper concentrate itself or a part of it can be pre-processed alone or together with flue dust prior to direct-to-blister copper flash smelting so that the thus obtained calcine acts both as a coolant and as at least a part of the smelting feed mixture for the copper smelting step for controlling the temperature in the smelting furnace in order to prevent overheating.

10 It was further realized that adjacent to pre-processing of the copper concentrate flue dust resulting from the copper smelting can be roasted together with the copper concentrate. In the roasting process at least part of the volatile impurities, such as arsenic, are volatilized and thus at least partly removed from the process to off gas. The copper concentrate can thus act as a
15 thermal energy source for the flue dust treatment while it is simultaneously dried and partially oxidized.

The present invention makes it feasible to use chalcopyrite concentrates for direct-to-blister copper smelting process for directly obtaining raw copper, and in addition to this, the accumulated flue dust can be treated in order
20 to remove impurities.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

25 Figure 1 illustrates a direct-to-blister copper flash smelting process where all of the copper concentrate is partially roasted before smelting;

Figure 2 illustrates a direct-to-blister copper flash smelting process where part of the copper concentrate is dead roasted and then combined with the rest of the untreated copper concentrate prior to smelting;

30 Figure 3 illustrates a direct-to-blister copper flash smelting process where copper concentrate is roasted together with flue dust using partial roasting to remove at least part of the volatile impurities.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a process of direct-to-blister flash smelting of copper concentrate, in particular copper concentrate which comprises chalcopyrite, comprising the steps of:

- 5 (a) providing copper concentrate;
- (b) roasting at least part of the copper concentrate, together with flue dust to at least partly remove volatile impurities, such as arsenic, comprised in the said flue dust, at an elevated temperature and under oxidizing atmosphere to at least partly oxidize the copper concentrate to obtain a cal-
- 10 cine; and
- (c) direct-to-blister flash smelting a smelting feed mixture comprising calcine obtained by the roasting step (b) as a coolant, and optionally untreated copper concentrate.

The process of the present invention is particularly suitable for cop-
15 per concentrates having high iron content, such as concentrates wherein the Cu:Fe ratio is from 0.7 to 2, preferably from 1.1 to 1.2, calculated from respective weight percentages. Chalcopyrite is a preferred example of such concentrates. Chalcopyrites are copper iron sulfide minerals having general chemical composition CuFeS_2 . These minerals contain sulfide (S^{2-}) as the major anion.
20 The presence of pyrite FeS_2 provides these minerals a high heat value as its oxidation is exothermic.

The pretreatment of the roasting step (b) decreases the heat value of the feed material i.e. copper concentrate and thus provides an endothermic coolant that can be used for controlling the energy balance of the smelting the
25 smelting step (c).

Furthermore, as a consequence of the roasting step (b) the copper concentrate is dried. Thus the process of the present invention is particularly suitable for wet copper concentrates. The term "wet copper concentrate" used herein and hereafter refers to copper concentrate having water content from 5
30 to 15% w/w. The energy needed to dry the copper concentrate is obtained by exothermic oxidation reactions of iron and copper containing sulfides. Therefore if most or all of the copper concentrate is pretreated in accordance with the present invention a separate step of drying of the copper concentrate in the copper smelting process is not needed at all. On entry to the roasting step (b)
35 the copper concentrate advantageously has water content below 15% w/w, preferably from 5 to 12% w/w, more preferably from 6 to 8% w/w.

To allow the utilization of copper concentrates which are higher in iron roasting of the concentrate i.e. the roasting step (b) of the present invention is carried out with such amount of oxygen and at such temperatures that at least part of the iron and/or copper containing sulfides in the concentrate is oxidized. In an example of the present invention the temperature of the roasting step (b) is from 600 to 800°C, preferably from 650 to 750°C, more preferably from 680 to 700°C.

The conversion of sulfides into sulfates and/or oxides with oxygen is dependent on the local oxygen concentration and temperature. Oxygen can be introduced into the roasting step (b) for example as air, oxygen enriched air, preferably as oxygen enriched air. The required amount of oxygen in the roasting step (b) depends on the sulfide content of the copper concentrate and desired heat value of the pretreated concentrate.

The partial oxidation of the copper and/or iron containing sulfides in the concentrate to corresponding copper and/or iron containing sulfates and/or oxides decreases the sulfur concentration and thus the heat value of the treated copper concentrate, and the obtained copper and/or iron containing sulfates and/or oxides further act as coolants since they require energy as they melt during the smelting the smelting step (c).

The term "roasting" used herein and hereafter is understood to refer to any one of sulfatizing roasting, partial roasting, and dead roasting. The preferred roasting method is dependent on the iron content of the copper concentrate and the amount of untreated copper concentrate fed into the smelting the smelting step (c). The term "calcine" as used herein and hereafter refers to a product obtained by heating a concentrate to a high temperature but below the melting or fusing point, causing loss of moisture, and at least partial the oxidation of sulfides and optionally other compounds comprised in the concentrate.

In the roasting step (b) the copper concentrate is roasted together with flue dust to at least partly remove volatile impurities, such as arsenic and optionally antimony and/or bismuth, comprised in the said flue dust. Thus the roasting step (b) further decreases the concentration of volatile impurities over the entire copper smelting process.

The flue dust treated by the process of the invention is produced during direct-to-blister copper flash smelting, i.e. in the smelting step (c). During the roasting step (b) the undesired impurities, such as arsenic and optionally antimony and/or bismuth, contained in the flue dust are volatilized at least

partly and thus correspondingly removed from the flue dust to roasting off gas. The volatilized impurities can be recovered from the off gas by methods known by the person skilled in the art.

5 The flue dust resulting from the smelting step (c) is preferably collected as dry and is either recirculated back to the smelting step or micropelletized so that fine dust can be treated by roasting in step (b) for removing volatile impurities accumulated in the said dust. The flue dust cannot be suspended to form a slurry as that would result in dissolution of sulfates contained in the flue dust.

10 In a preferred example of the present invention the flue dust is micropelletized as such or together with the copper concentrate before the roasting step (b). Micropelletizing will avoid major loss of flue dust to the off gas and is thus highly advantageous. Micropelletizing also enables utilization of a wider variety of roasting methods. Micropelletizing can be accomplished by any suitable method known to a person skilled in the art, for example by pelletizing
15 drum or disc pelletizer. The micropellets introduced into the roaster, i.e. the roasting step (b), should preferably be within the size range of 20 to 2000 μm , preferably from 50 to 500 μm , more preferably from 70 to 200 μm .

20 The micropelletized mixture of flue dust and copper concentrate introduced into the roasting stage (b) as fluidized particles acts as an energy carrier itself due to the exothermic oxidation of the sulfide contained in the copper concentrate. Thus no other source of thermal energy is required for the desirable progression of the roasting step (b).

25 The roasting step (b) can be performed in any roaster found suitable by a person skilled in the art. The roasting step can for example be carried out in a roaster selected from the group consisting of a rotary kiln, a fluidized bed reactor, such as a bubbling fluidized bed roaster, a circulating fluidized bed roaster, an annular fluidized bed roaster, and a flash reactor. In accordance with an advantageous example of the present invention roasting in the roasting
30 step (b) is carried out in a fluidized bed reactor. This ensures a very good mass and heat transfer.

The copper smelting the smelting step (c) can be accomplished by methods known by a person skilled in the art. The smelting step can be performed in any smelting furnace found suitable by a person skilled in the art.
35 The smelting step can for example be carried out in a smelting furnace selected from the group consisting of a flash smelting furnace, a flash converting

furnace, and a pyrometallurgic furnace. In a particularly suitable example of the process of the present invention, the smelting of the smelting step (c) is flash smelting. In a preferred example of the process of the present invention, the smelting of the smelting step (c) is direct-to-blister smelting. Adjustment of the heat value of the copper concentrate melted in direct-to-blister smelting is particularly desirable as the problem controlling of the energy balance of the direct-to-blister flash smelting process is particularly pronounced.

The feed of the smelting the smelting step (c) is either calcine obtained by the roasting step (b) of the process of the invention, or, when only part of the copper concentrate is converted into said calcine, a mixture of said calcine and untreated copper concentrate. The term "untreated copper concentrate" used herein and hereafter refers to copper concentrate not treated in accordance with the roasting step (b) of the process of the present invention. The untreated copper concentrate can however be preprocessed by other suitable methods before mixing with the calcine, if so required. However, with the process of the invention, the necessity to dry wet copper concentrate before its introduction into the smelting the smelting step (c) is preferably avoided. And therefore, preferably, the untreated copper concentrate is not dried before it is introduced into the smelting the smelting step (c) together with the calcine. The energy balance of the smelting process can be controlled by adjusting the ratio of the calcine and the untreated concentrates as well as by careful selection of the roasting method and conditions of the roasting step (b). When the calcine is mixed with untreated copper concentrate the calcine obtained by the roasting step (b) is preferably dead roasted. When all copper concentrate is roasted in the roasting step (b) and calcine is thus introduced into the smelting step (c) without mixing with untreated copper concentrate, the calcine obtained by the roasting step (b) is preferably partially roasted. On entry into the smelting the smelting step (c) the smelting feed mixture comprising calcine obtained at least partly by the roasting step (b) advantageously has water content below 0.5% w/w, preferably below 0.1% w/w.

Sulfur oxidized in the roasting step (b) forms an SO₂ containing gas that can be treated in an acid plant together with the gas coming from the smelting the smelting step (c) or separately. Furthermore, flue dust produced in the smelting step (c) can be further recycled back into the roasting step (b).

The present invention further relates to use of calcine obtained by the roasting step (b) of process of the invention as coolant in copper flash smelting, in particular in direct-to-blister smelting.

Figure 1 illustrates a first example of the present invention wherein wet copper concentrate (1) is dried and controllably partially roasted in a fluidized bed furnace before smelting. All of wet copper concentrate to be processed in the direct-to-blister flash smelting the smelting step (c) is introduced into the roasting step (b) wherein it is contacted with air or oxygen enriched air (2) under an elevated temperature and controlled partial roasted to produce a calcine (3) comprising enough sulfides for heating and smelting the calcine in the reaction shaft of the flash smelting furnace in the direct-to-blister copper flash smelting the smelting step (c) when high oxygen enrichment for minimizing gas flow is used. There is the possibility to crush the material, in case lumps will form (20).

The off gas obtained by the roasting step (b) can be treated in cyclone (21) to remove any retained solid particles, treated in an afterburner (22) and cooled (23) and treated by a bag filter (24) for dust removal. The thus obtained a first purified SO_2 containing gas (4) can be sent to acid plant for production of sulfuric acid. The blister (5) obtained by the smelting step (c) can be thermally refined in an anode furnace (30), which can be followed by electrolytic refining (31) whereby a copper cathode (6) is obtained. The off gas from the smelting step (c) can be treated in a boiler (32) and HESP (33) to obtain a second purified SO_2 -containing gas (4') which can be sent to acid plant for production of sulfuric acid. The slag (7) obtained by the smelting step (c) can be further treated in slag cleaning (34).

Figure 2 illustrates a second example of the present invention wherein part of the wet copper concentrate is dried and roasted in a fluidized bed furnace before smelting in the smelting step (c). In Figure 2, like components are designated by the same reference signs as used in Figure 1. Part of the wet copper concentrate (1') to be smelted in a direct-to-blister flash smelting the smelting step (c) is fed into a roasting step (a) wherein in it is contacted with air or oxygen enriched air (2) under an elevated temperature. The wet concentrate is dead roasted i.e. the material is fully oxidized so that the obtained calcine does not contain any sulfides. It has thus lost its heat value and can therefore act as a coolant in the flash smelting furnace in the copper flash smelting the smelting step (c) when it is mixed with the remaining part of the

untreated copper concentrate (1''). The wet untreated concentrate (1'') if preferably dried before entering to the smelting step (c) in presence of an energy source (8). Heating and smelting in the reaction shaft in the smelting step (c) is carried out using concentrate and high oxygen enrichment for minimization of the gas flow and calcine as a coolant to control the heat balance of the reaction shaft.

Figure 3 illustrates a third example of the present invention wherein wet copper concentrate (1) is micropelletized (40) together with flue dust (9) to obtain micropelletized feed material (10). In Figure 3, like components are designated by the same reference signs as used in Figure 1. The micropelletized feed material (10) is then introduced into the roasting step (b) wherein it is partially roasted as discussed with reference to Figure 1. The process gas in the roaster is air or oxygen enriched air (2). The thus obtained calcine (3) is then processed discussed with reference to Figure 1.

EXAMPLE

Example 1

The following example illustrates by estimation a process where part of a wet copper concentrate mixed with flue dust is dried and roasted in a roaster before direct-to-blister flash smelting. 70 t/h of a mixture of wet copper concentrate comprising Cu 28.3% w/w, Fe 22.9% w/w, S 30.3% w/w, As 0.39% w/w, CaO 0.26% w/w and SiO₂ 11.2% w/w and flue dust comprising Cu 23.7% w/w, Fe 16.6% w/w, S 14.6% w/w, As 1.1% w/w, CaO 1.0% w/w and SiO₂ 4.5% w/w is introduced into a roasting step wherein in it is contacted with 38000 Nm³/h process air (O₂ = 25%) under a temperature of 680°C. A calcine comprising Cu 35.0% w/w, Fe 27.6% w/w, S 8.7% w/w, As 0.10% w/w, CaO 0.53% w/w and SiO₂ 12.5% w/w is obtained.

The calcine (53.8 t/h) is then fed into a direct-to-blister furnace where it is mixed with 60 t/h of untreated copper concentrate which is dried before entering into the smelting furnace to residual moisture of 0.2%. Smelting in the reaction shaft in the smelting step (c) is carried out using 48200 Nm³/h process oxygen. 19.6 t/h of blister comprising Cu 98.9% w/w, Fe 0.07% w/w, S 0.30% w/w, and As 0.38% w/w; and 75.7 t/h of slag comprising Cu 17.9% w/w, Fe 34.5% w/w, S 0.15% w/w, As 0.07% w/w, CaO 5.0% w/w and SiO₂ 17.1% w/w is thus obtained.

As can be seen from the estimation, the roasting step of the present invention lowers the arsenic content of the smelting feed mixture. Also the sulfur content of the smelting feed mixture is significantly lowered, and the thus obtained calcine can act as a coolant in the smelting step.

- 5 It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A process for direct-to-blister flash smelting of copper concentrate, comprising the steps of:

(a) providing copper concentrate;

5 (b) roasting at least part of the copper concentrate, together with flue dust to at least partly remove volatile impurities, such as arsenic, comprised in the said flue dust, at an elevated temperature and under oxidizing atmosphere to at least partly oxidize the copper concentrate to obtain a calcine; and

10 (c) direct-to-blister flash smelting a smelting feed mixture comprising calcine obtained by the roasting step (b) as a coolant, and optionally untreated copper concentrate.

2. The process as claimed in claim 1, wherein the flue dust is micropelletized.

15 3. The process as claimed in claim 1, wherein the flue dust is micropelletized together with the copper concentrate before the roasting step (b).

4. The process as claimed in claim 2 or 3, wherein the micropellets introduced into the roasting step (b) are within the size range of 20 to 2000 μm , preferably from 50 to 500 μm , more preferably from 70 to 200 μm .

20 5. The process as claimed in any one of claims 1 to 4, wherein the elevated temperature is from 600 to 800°C, preferably from 650 to 750°C, more preferably from 680 to 700°C.

25 6. The process as claimed in any one of claims 1 to 5, wherein the oxidizing atmosphere is introduced as air, or oxygen enriched air, preferably as oxygen enriched air.

7. The process as claimed in any one of claims 1 to 6, wherein the copper concentrates has a Cu:Fe ratio is from 0.7 to 2, preferably from 1.1 to 1.2, calculated from respective weight percentages.

30 8. The process as claimed in any one of claims 1 to 7, wherein the copper concentrate comprises chalcopyrite.

9. The process as claimed in any one of claims 1 to 8, wherein at least part of the copper and/or iron containing sulfides in the copper concentrate are oxidized to corresponding copper and/or iron sulfates and/or oxides in the roasting step (b).

10. The process as claimed in any one of claims 1 to 9, wherein the roasting step (b) is carried out in a fluidized bed reactor.

11. The process as claimed in any one of claims 1 to 10, wherein the copper concentrate introduced into the roasting step (b) has a water content below 15% w/w, preferably from 5 to 12% w/w, more preferably from 6 to 8% w/w.

12. The process as claimed in any one of claims 1 to 11, wherein the flue dust is produced during copper smelting, i.e. in the smelting step (c).

13. Use of calcine obtained by the roasting step (b) of the process as defined in any one of claims 1 to 12 as a coolant in direct-to-blister flash smelting.

FIG 1

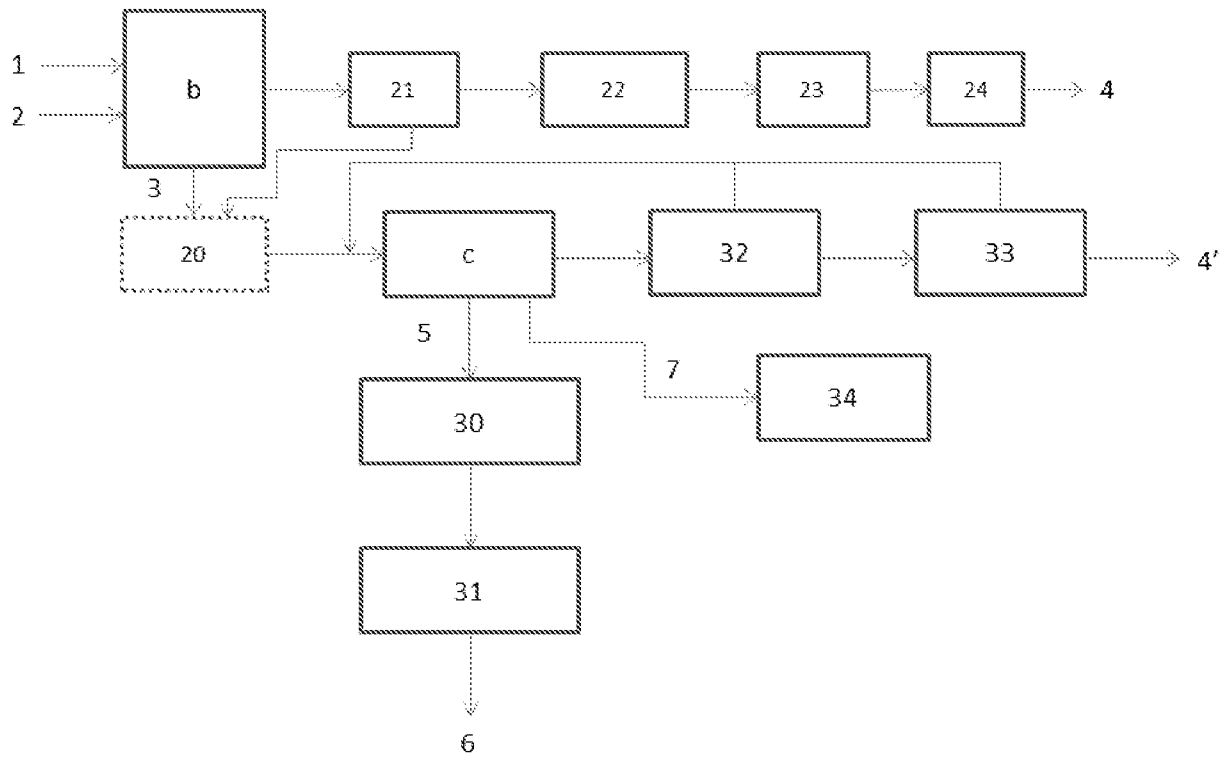


FIG 2

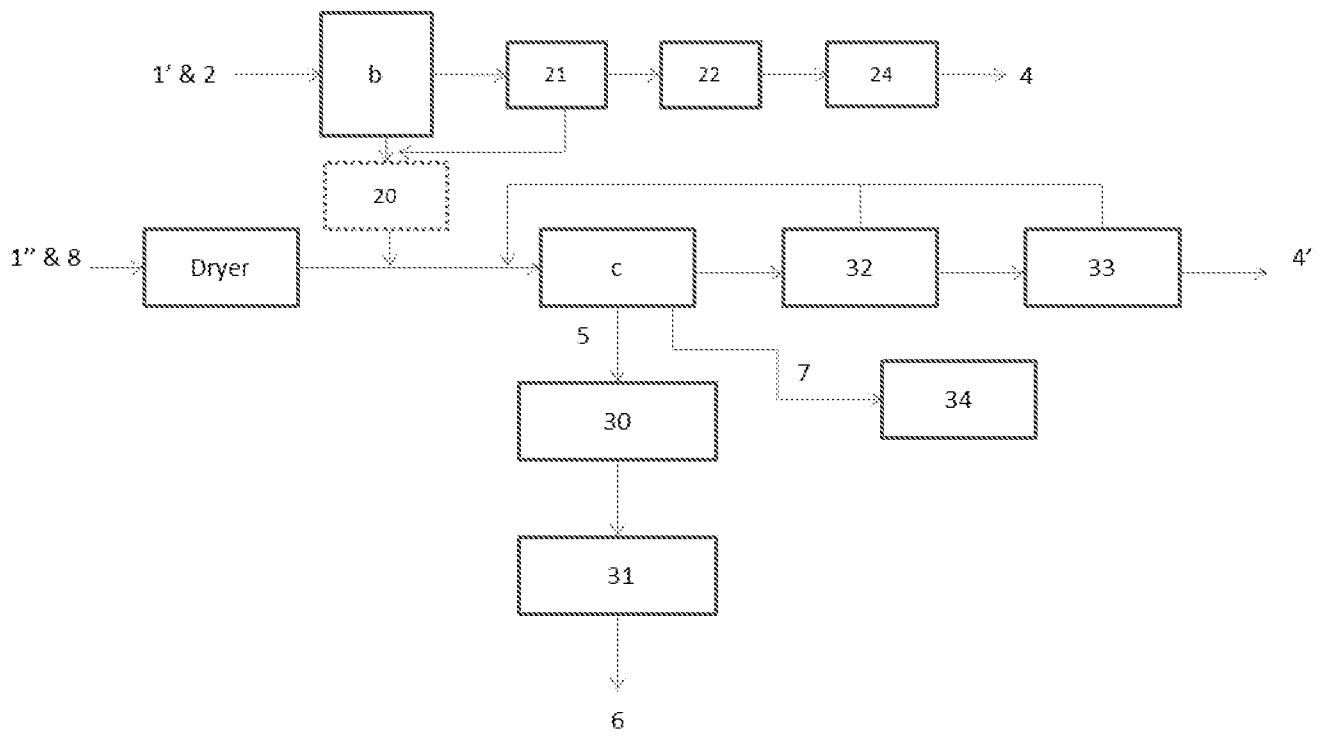
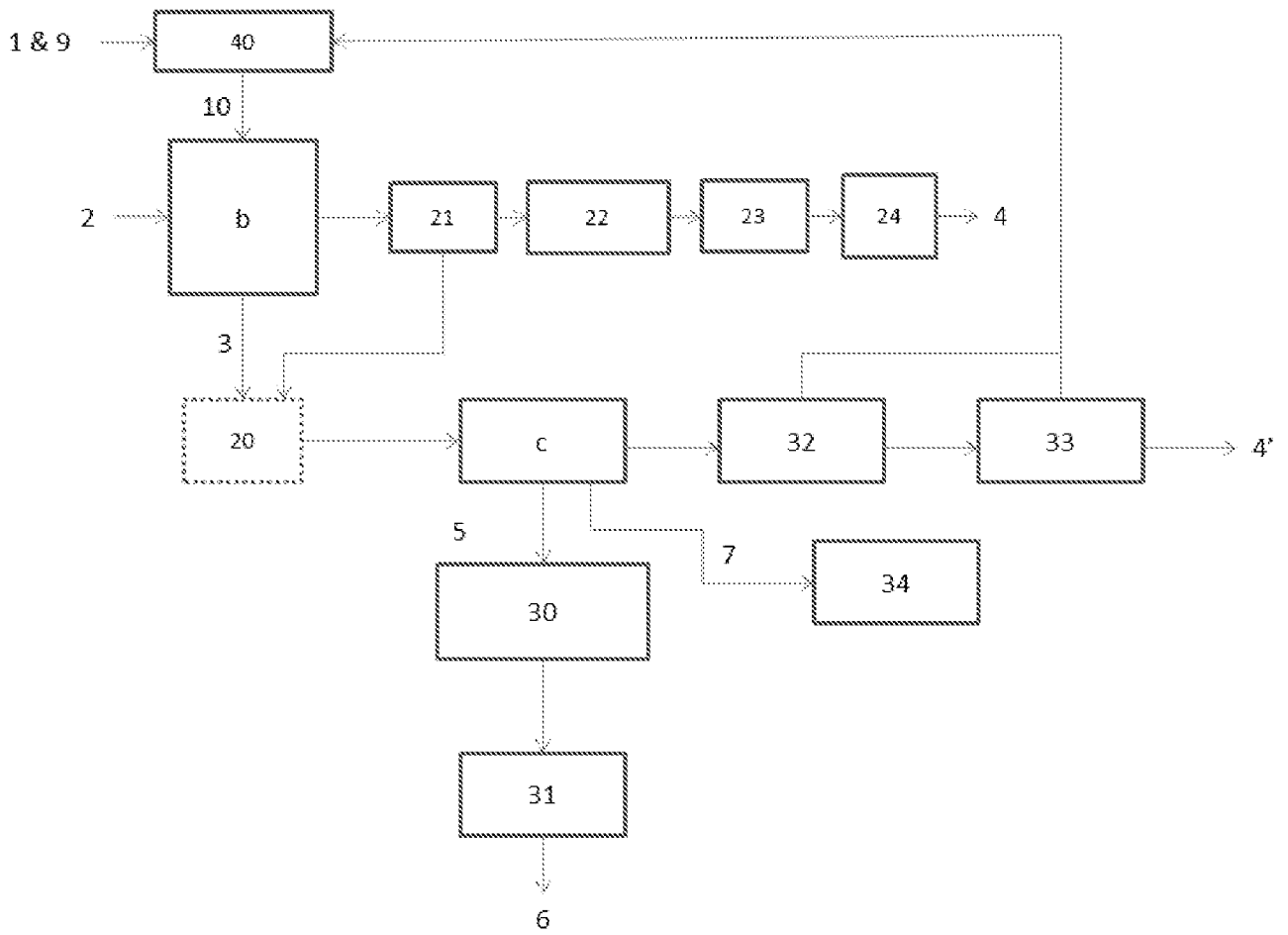


FIG 3



INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2014/050887

A. CLASSIFICATION OF SUBJECT MATTER

INV. C22B15/00

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)

C22B

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	US 4 615 729 A (VICTOROVICH GRIGORI S [CA] ET AL) 7 October 1986 (1986-10-07) the whole document -----	13
X	US 4 421 552 A (HOFFMANN JAMES E [US] ET AL) 20 December 1983 (1983-12-20) the whole document -----	13
A	GB 2 161 835 A (OUTOKUMPU OY) 22 January 1986 (1986-01-22) the whole document -----	1-13
A	WO 2012/059646 A1 (OUTOTEC OYJ [FI]; MYYRI JORMA [FI]; AHOKAINEN TAPIO [FI]; PESONEN LAUR) 10 May 2012 (2012-05-10) cited in the application the whole document -----	1-13

☐

Further documents are listed in the continuation of Box C.

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See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4615729	A	07-10-1986	CA 1234696 A1	05-04-1988
			FI 861107 A	21-09-1986
			JP S61221339 A	01-10-1986
			US 4615729 A	07-10-1986

US 4421552	A	20-12-1983	CA 1202184 A1	25-03-1986
			DE 3313088 A1	20-10-1983
			JP S58189341 A	05-11-1983
			US 4421552 A	20-12-1983

GB 2161835	A	22-01-1986	AU 575415 B2	28-07-1988
			AU 4480085 A	23-01-1986
			CA 1247373 A1	27-12-1988
			DE 3525710 A1	30-01-1986
			GB 2161835 A	22-01-1986
			JP S6137929 A	22-02-1986
			JP S6350409 B2	07-10-1988
			US 4599108 A	08-07-1986
			US 4645186 A	24-02-1987

WO 2012059646	A1	10-05-2012	AR 083703 A1	13-03-2013
			CA 2815411 A1	10-05-2012
			CL 2013001216 A1	06-12-2013
			CN 103189528 A	03-07-2013
			CN 202452831 U	26-09-2012
			EA 201390429 A1	29-11-2013
			EP 2635718 A1	11-09-2013
			FI 20106156 A	05-05-2012
			JP 2014500940 A	16-01-2014
			KR 20130101561 A	13-09-2013
			US 2013328250 A1	12-12-2013
			WO 2012059646 A1	10-05-2012
