A method of continuous conversion of copper matte is described. The process involves the oxidation of iron sulphide and subsequent oxidation of copper sulphide with the formation of copper blister, which is carried out discontinuously in Pierce-Smith or Hoboken converters. The present invention resolves said difficulty by making the industrial process a continuous operation. The method consists in the use of a continuous gravitational flow of copper matte to two reactors connected in series by a channel, in which oxidation and slagging of the iron in the copper matte is performed in the first reactor, followed by oxidation of the copper sulphide and formation of copper blister in the second reactor. Said intensive operation for converting liquid or liquid and solid copper matte is continuous and uses packed beds with a view to increasing the oxidation rate, in each reactor, with shorter operating times.
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(54) Title: METHOD FOR CONTINUOUS CONVERSION OF COPPER MATTE - SPECIFICATION

(54) Título: MÉTODO DE CONVERSIÓN CONTÍNUA DE MATA DE COBRE

(57) Abstract: The industrial practice of converting copper matte comprises the oxidation of iron sulphide and subsequent oxidation of copper sulphide with the formation of copper blister, which is carried out discontinuously in Pierce-Smith or Hoboken converters. The present invention resolves said difficulty by making the industrial process a continuous operation. The method consists in the use of a continuous gravitational flow of copper matte to two reactors connected in series by a channel, in which oxidation and slagging of the iron in the copper matte is performed in the first reactor, followed by oxidation of the copper sulphide and formation of copper blister in the second reactor. Said intensive operation for converting liquid or liquid and solid copper matte is continuous and uses packed beds with a view to increasing the oxidation rates, in each reactor, with shorter operating times.
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(57) Resumen: La práctica industrial de conversión de mata de cobre es la oxidación del sulfuro de hierro y posterior oxidación del sulfuro de cobre con formación de cobre blister, efectuada en convertidores Peirce-Smith u Hoboken en modo discontinuo. La presente invención resuelve dicha dificultad estableciendo continuidad operacional al proceso industrial. El método consiste en el uso de un flujo gravitacional continuo de mata de cobre a dos reactores conectados en serie por una canal, en donde la oxidación y escorificación del hierro de la mata de cobre se efectúa en el primer reactor seguida por oxidación del sulfuro de cobre y formación de blister en el segundo reactor. Dicha operación intensiva de conversión de mata de cobre líquido ó líquido y sólido es continua utilizando se lechos empacados para incrementar la tasa de oxidación, en cada reactor, con menores tiempos de operación.
SUMMARY

The copper matte conversion industrial practice consists of the oxidation of iron sulfur, and subsequent oxidation of copper with formation of blister copper in Peirce-Smith or Hoboken converters, in a discontinued mode. This invention solves said difficulty by providing continuity to the industrial process. The method consists of the usage of a copper matte continuous gravitational flow to two reactors connected in series by a channel, where the oxidation and slagging of the iron contained in the copper matte takes place in the first reactor, and is followed by the oxidation of copper sulfur and formation of blisters in the second reactor. Said intensive conversion of liquid or liquid and solid copper matte is continuous, as packed beds are used for increasing the oxidation rate in each reactor in a reduced operating time.
METHOD OF CONTINUOUS CONVERSION OF COPPER MATTE

DESCRIPTIVE MEMORY

BACKGROUND

Smelting of copper concentrates produces matte and slag. Copper matte is converted into blister copper in the Peirce-Smith or Hoboken converters or, otherwise, in continuous conversion process such as the Kennecott-Outokumpu, the Mitsubishi or the Noranda processes. Blister copper is directed to fire refining process prior to the electro-refining.

The classic discontinuous conversion process of copper matte is developed in a vascular furnace called Peirce-Smith converter or in a vascular furnace with an off-gas siphon called Hoboken converter. The classic process (batch) is discontinued and consists in two stages: iron slagging and molding of blisters.

The first conversion stage aims at removing the FeS from the Cu₂S-FeS solution and the slagging of iron oxides by adding siliceous flux.

\[(\text{FeS})_{\text{matte}} + 1,5\text{O}_2 + \text{SiO}_2 \rightarrow (\text{Fe}_2\text{SiO}_3)_{\text{slag}} + \text{SO}_2\]

The Mitsubishi and Kennecott-Outokumpu continuous conversion processes use limestone as flux, which forms calcium ferrite slag.

\[2(\text{FeS})_{\text{matte}} + 3,5\text{O}_2 + \text{CaO} \rightarrow (\text{CaOFe}_2\text{O}_3)_{\text{slag}} + 2\text{SO}_2\]

After removing the slag by blowing air or enriched air, it is conducted to precipitation of metallic copper (blister copper).

\[(\text{Cu}_2\text{S})_{\text{matte}} + \text{O}_2 \rightarrow 2(\text{Cu})_{\text{blister}} + \text{SO}_2\]

The classic conversion in a Peirce-Smith converter has the operational flexibility of a typical discontinuous process, low energetic efficiency, high labor requirements, and high emissions of sulfur dioxide and volatile
impurities. The temperature fluctuation and the thermal impact shorten the life of the refractory, especially in the tuyeres area.


Outokumpu and Kennecott developed the continuous flash conversion process. This process began to be industrially used in 1996 at the Kennecott smelter. The process uses the Outokumpu flash furnace for oxidation of high-grade powdered matte directly to blister copper. Limestone is used as

The other continuous conversion process was put into operation by the Noranda company in 1997. The Noranda Continuous Conversion process uses Noranda's reactor for continuous oxidation of the copper matte, by maintaining three layers inside the reactor: one of semi-blister, one of white metal and one of slag. Use of siliceous flux produces fayalite slag saturated in magnetite. The process is not fully continuous. For obtaining blister copper, final blowing must be performed the Peirce-Smith converter.

BRIEF DESCRIPTION OF DRAWING

Figure: schematic diagram showing the side view, elevation and profile of the intensive pyrometallurgical method of continuous conversion of copper matte in two cascade packed-bed reactors.

DESCRIPTION OF INVENTION

This invention refers to a pyrometallurgical method for the continuous conversion of copper matte by using a flow of gravitational liquid matte in two reactors installed in series.

This invention drives to a continuous conversion method of copper matte consisting of the following stages:

Liquid copper matte (4) is transferred from a melting furnace through a channel to the first oxidation reactor (3) or solid matte is loaded (6) directly over the packed bed surface in the first reactor;

Loading of limestone and silica solid fluxes (6) over the packed bed of the first reactor;

Dispersion and gravitational flow of liquid matte through a ceramic grain packed bed;

Injection of air and oxygen-rich air through the tuyeres (2) in countercurrent to the liquid matte flow going upwards inside the packed-bed;

Oxidation of iron sulfur:

\[(\text{FeS})_{\text{matte}} + 1.5\text{O}_2 \rightarrow (\text{FeO})_{\text{solid}} + \text{SO}_2\]
\[3(\text{FeS})_{\text{matte}} + 5\text{O}_2 + \text{CaO} \rightarrow (\text{Fe}_3\text{O}_4)_{\text{solid}} + 3\text{SO}_2\]
Slag formation:

\[
\text{CaO} + \text{SiO}_2 \rightarrow (\text{CaSiO}_3)_{\text{slag}} \\
2(\text{FeO})_{\text{solid}} + \text{SiO}_2 \rightarrow (\text{Fe}_2\text{SiO}_4)_{\text{slag}} \\
2(\text{Fe}_3\text{O}_4)_{\text{solid}} + (\text{FeS})_{\text{matte}} + \text{SiO}_2 \rightarrow 3(\text{Fe}_2\text{SiO}_4)_{\text{slag}} + \text{SO}_2 \\
(\text{Fe}_2\text{O}_4)_{\text{solid}} + \text{CaO} \rightarrow (\text{CaO.Fe}_2\text{O}_3)_{\text{slag}} + \text{FeO}
\]

Slag and white metal separation on bottom of the reactor;

Conversion slag continuous extraction through a tapping hole (1) and white metal continuous extraction through a siphon or inclined hole;

Recycle of conversion slag to the melting furnace or to the slag-cleaning furnace;

Continuous transfer of white metal (copper sulfur) through a channel (7) to a second reactor of copper sulfide oxidation (9);

Dispersion and gravitational flow of white metal through a ceramic grain packed bed;

Injection of air or oxygen-rich air through tuyeres (10);

Oxidation of white metal with molding of blister copper

\[
(\text{Cu}_2\text{S})_{\text{matte}} + \text{O}_2 \rightarrow 2(\text{Cu})_{\text{blister}}
\]

Transfer of blister copper (11) through a channel to fire refining;

Evacuation of the off gases of the iron oxidation reactors (5) and of copper mold (8) to the general system of gas cleaning of the smelter and to the sulfuric acid plant;
The process' principle is schematically illustrated in Figure 1. The copper matte (4) dispersed on the surface of the ceramic bed, flows downwards in form of small drops and veins that get in contact with the countercurrent flow of hot gas containing oxygen. An extremely high ratio of liquid matte surface area (4) in relation to its volume results in a high rate of oxidation. Iron oxidation produces iron oxides that combine with the flux and form the slag. The oxidation parameters, quantity of oxygen and temperature can be precisely controlled by the flow of rich air blown through the tuyeres (2). Similarly, the dispersion of the white metal (7) over the ceramic grain packed bed of the second reactor increases the reaction surface area, which in combination with the oxygen injected through the tuyeres (10) in countercurrent to the liquid flow, results in a very high rate of copper sulfide oxidation, and forms blister copper. The temperature of the reactor can be precisely controlled by the flow of injected air.

This invention has the following advantages as compared to the traditional copper matte conversion methods:

Investment costs are significantly lower due to the small size of the reactors required for the same production capacity;

Reduced labor requirements due to the totally continuous operation mode;

Improved safety conditions for operators due to reduced work exposed to high temperatures;

A more precise control of the process is achieved due to the reduced inertia of the system. The grade of oxidation of the matte, and temperature of
the matte and slag can be precisely maintained within a narrow operating range.

No liquid products need to be transported by crane, and no solid products formation must be returned to the process;

The impurities removal ration is high due to the development of the surface area, which allows obtaining blister copper of better quality.

Stationary condition of the reactors allows their easy pressurization, and thereby fugitive emissions of sulfur dioxide and volatile impurities are drastically reduced.

This invention has the following advantages as compared to the copper matte continuous conversion existing methods:

Investment costs are significantly lower due to the small size of the reactors required for the same production capacity;

Continuity of production can be assured with two parallel lines of reactors, one in operation, the second in maintenance or on hold, thanks to the low construction cost of the same;

Usage of MgO saturated olivine slag when using discard magnesite-chrome bricks allows reducing corrosion of the reactor’s refractory reactor. The usage of tuyeres to inject oxygen-rich air directly into the porosity of the packed bed does not destroy the refractory in the tuyeres area;

A more precise control of the process is achieved due to the reduced inertia of the system. The grade of oxidation of the matte, and temperature of
the matte and slag can be precisely maintained within a narrow operating range.

EXAMPLE N° 1

Copper matte with 73% - 75% of Cu continually flows through a channel from the tapping hole of the Teniente Converter into the first oxidation reactor (3) at a rate of 20 t/h. 3900 Nm³/h of air is blown and injected through the tuyeres (2) inside the packed bed. Over it, 0.68 t/h of quartz flux and 0.36 t/h of limestone flux are continuously charged. Off gases containing 11% of SO₂ and 5% of O₂ are permanently transferred to the gas cleaning system and to the acid plant. The slag (1) containing 6% of Cu, 40% of Fe, 15% of CaO and 30% of SiO₂, is continuously tapped out at a rate of 2.4 t/h. White metal (7) flows from the siphon block at a rate of 18.3 t/h to a channel of the second copper sulfide oxidation reactor (9). In the latter, oxygen-rich air (24% of O₂) is blown at 13,800 Nm³/h into the packed bed in countercurrent to the white metal. Off gas (8), 17.470 Nm³/h, containing 17.3% of SO₂ and 5.2% of O₂ is transferred to the gas cleaning system and to the acid plant. The blister copper produced (11), containing 3000 ppm of O₂ and 5000 ppm of S, flows through a channel of a siphon block to the copper fire-refining furnace.

EXAMPLE N° 2

Solid copper matte (73% - 75% of Cu) with a 20 – 50 mm grain size is fed over the packed bed surface of the oxidation reactor (3) at a rate of 20 t/h together with the limestone flux (0.36 t/h) and siliceous flux (0.68 t/h) (6). Oxygen-rich air (85% of O₂) is blown at 2400 Nm³/h through the tuyeres to the packed-bed. Off gases of this reactor (5) containing 80% of O₂ and 4% of O₂ are transferred to the gas cleaning system. Slag (1) containing 16% of Cu, 33% of Fe, 13% of CaO and 30% of SiO₂ is continuously extracted at a rate of 2.6 t/h. White metal and blister copper (7) flow at a rate of 16.1 t/h through a channel of the siphon block to a second reactor (9). In the latter, oxygen-rich
air (24% of O₂) is blown through the tuyeres (10) at 6750 Nm³/h into the ceramic grain packed bed. Off gas (8), 8920 Nm³/h, containing 18.4% of SO₂ and 5.3% of O₂ is transferred to the gas cleaning system and to the acid plant. Blister copper produced (11), containing 3000 ppm of O₂ and 5000 ppm of S, flows through a channel of the siphon block to the copper fire-refining furnace.
CLAIMS

1. The continuous intensive pyrometallurgical method for converting liquid copper mate in two reactors, CHARACTERIZES for having the following successive stages:

a. continuous feeding of liquid matte into the first oxidation reactor, which has a refractory chamber for containing said matte; said refractory chamber contains a ceramic grain packed bed or other chemically neutral grains over which said matte disperses and gravitationally flows through said packed bed;

b. simultaneous supply of gases containing air or oxygen-rich air through said ceramic grain packed bed, in countercurrent to the liquid matte, for oxidation of the iron sulfur;

c. simultaneous supply of siliceous, limestone or mixed flux for slagging iron oxides and impurities, with formation of a conversion olivine-type slag (CaO-SiO₂-FeO-Fe₂O₃), which gravitationally flows through the porous bed;

d. continuous tapping of conversion slag from a tapping hole, and copper sulfur from a siphon block or inclined hole from the furnace floor;

e. continuous feeding of white metal to a second oxidation reactor, which has a refractory chamber for containing said white metal; said refractory chamber contains a ceramic grain packed bed or other chemically neutral grains over which such white metal disperses and gravitationally flows through said packed bed;

f. simultaneous supply of gases containing air or oxygen-rich air through said ceramic grain packed bed, in countercurrent to the liquid white metal, for oxidation of the copper sulfur, with formation of blister copper, which flows gravitationally to the bottom of the reactor;
g. continuous tapping of blister copper from a tapping siphon block or inclined hole from the furnace bottom; and

h. continuous evacuation of SO₂-rich gases rich from the iron oxidation and copper formation reactor to sulfur acid plant.

2. Method as set forth in claim 1 CHARACTERIZES because the copper matte defined in (a) can be loaded in solid form over the surface of the packed-bed of the first reactor and melted with the hot gases flowing upwards from the bed.

3. Method set forth in claim 1 CHARACTERIZES because the copper matte defined in (a) can be charged in liquid form simultaneously with the solid copper matte over the surface of the packed bed of the first reactor.

4. Method set forth in claim 1 CHARACTERIZES because the oxygen-rich air defined in (b) of the air blown varies from 21% to 80%, depending on the loss of heat of the reactor, grade of the matte and solid or liquid feeding to assure an autogenic process.

5. Method set forth in claim 1 CHARACTERIZES because the flux added, as defined in (c), only consists of limestone and forms calcium ferrite slag.

6. Method set forth in claim 1 CHARACTERIZES because flux added, as defined in (c), consists of limestone, clay and quartz and form an anorthite-type slag (CaAl₂Si₂O₈).

7. Method set forth in claim 1 CHARACTERIZES because, as defined in (a), it may be charged over the packed bed surface the remainders of solid copper and returns of high-grade copper melted in countercurrent by the process gases, and collected by the white metal and slag.
8. Method set forth in claim 1 CHARACTERIZES because the oxygen-rich
defined in (f) of the air blown varies from 21% to 80%, depending on the
loss of heat of the reactor.