US 20100107820A1

(19) United States

(12) Patent Application Publication

Euston

(10) Pub. No.: US 2010/0107820 A1

(43) Pub. Date: May 6, 2010

(54) **METHOD FOR DRYING COPPER SULFIDE CONCENTRATES**

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(21) Appl. No.: **12/290,972**

(22) Filed: **Nov. 4, 2008**

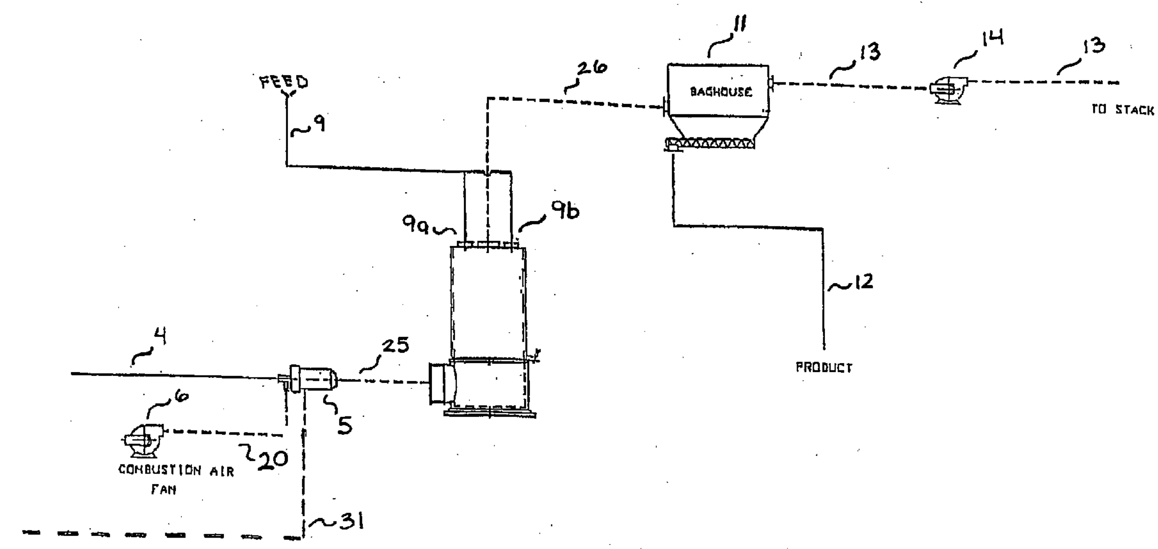
Publication Classification

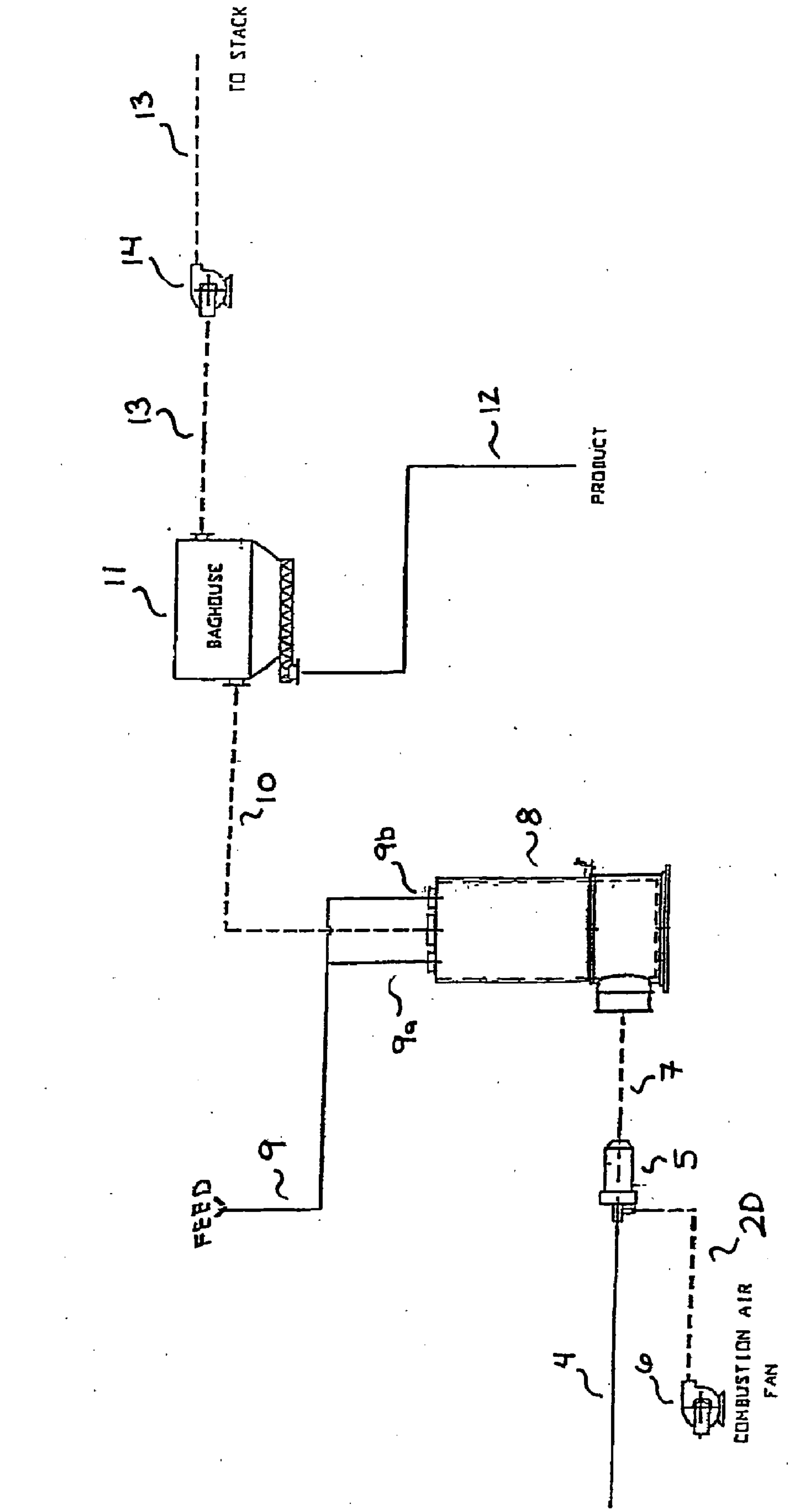
(51) **Int. Cl.**
C22B 15/00 (2006.01)
C22B 1/00 (2006.01)

(52) **U.S. Cl.** **75/638**; 75/392

(57) **ABSTRACT**

Dried copper concentrate is introduced to a smelter/converter that utilizes oxygen enrichment in the smelter/convert process. The copper concentrate was previously dried in a gas suspension or fluid bed dryer by contact with nitrogen gas that was a byproduct from the oxygen plants utilized to support the smelter.




TO STACK
13
14
13
11
BAGHOUSE
12
PRODUCT
10
9b
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9a
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FEED
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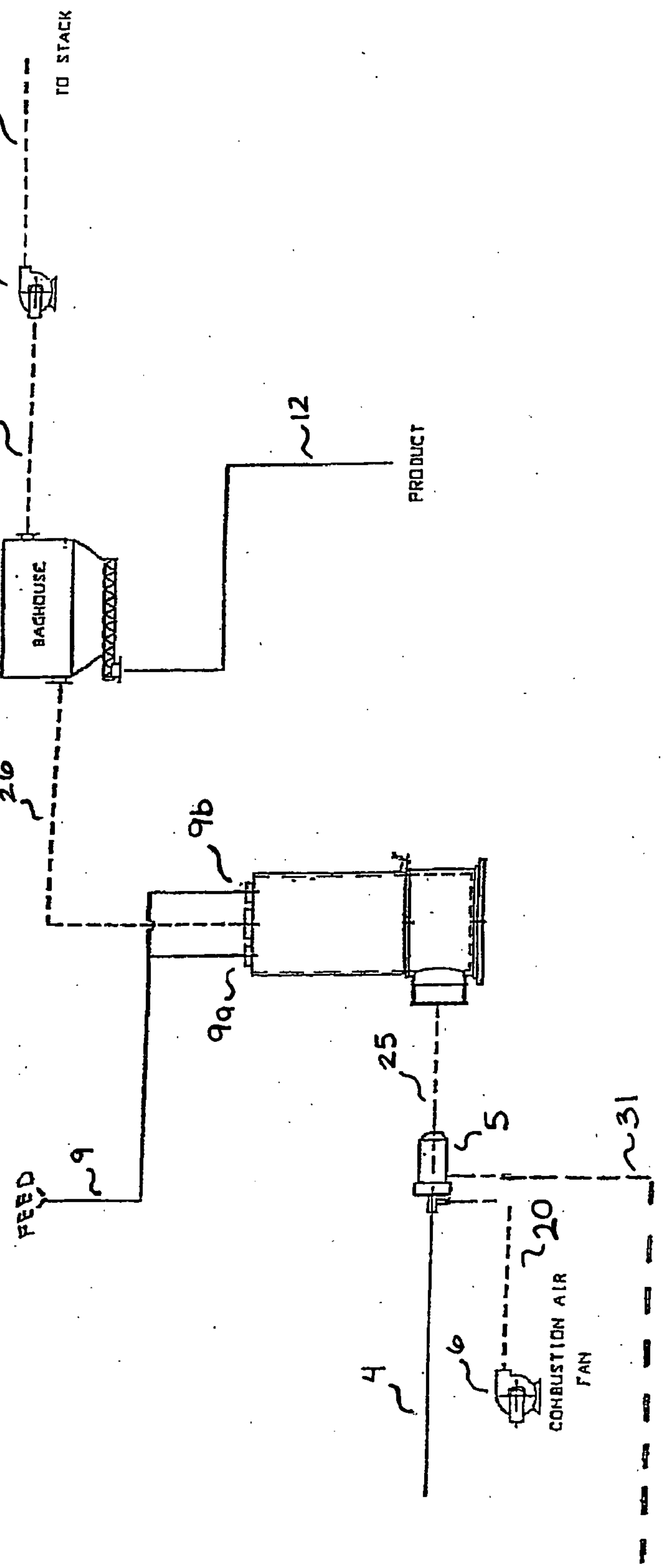
COMBUSTION AIR
FAN
4

FIGURE 1


TO STACK
13
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BAGHOUSE
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26
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20
COMBUSTION AIR FAN
6
4

FIGURE 2

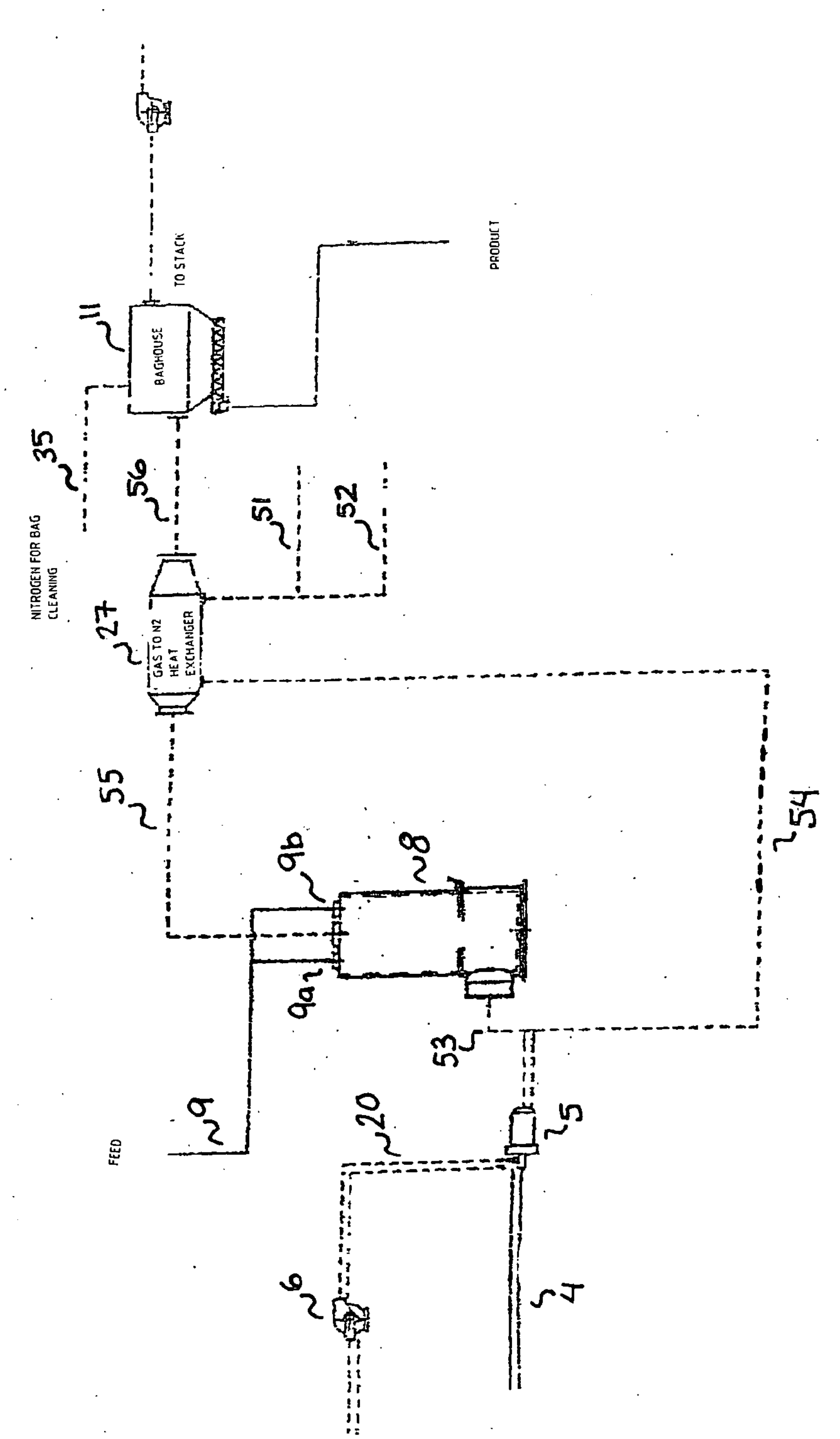
NITROGEN FOR BAG CLEANING
35
11
BAGHOUSE
TO STACK
PRODUCT
56
51
52
27
GAS TO N2 HEAT EXCHANGER
55
9b
8
9a
53
54
FEED
9
20
5
6
4

FIGURE 3

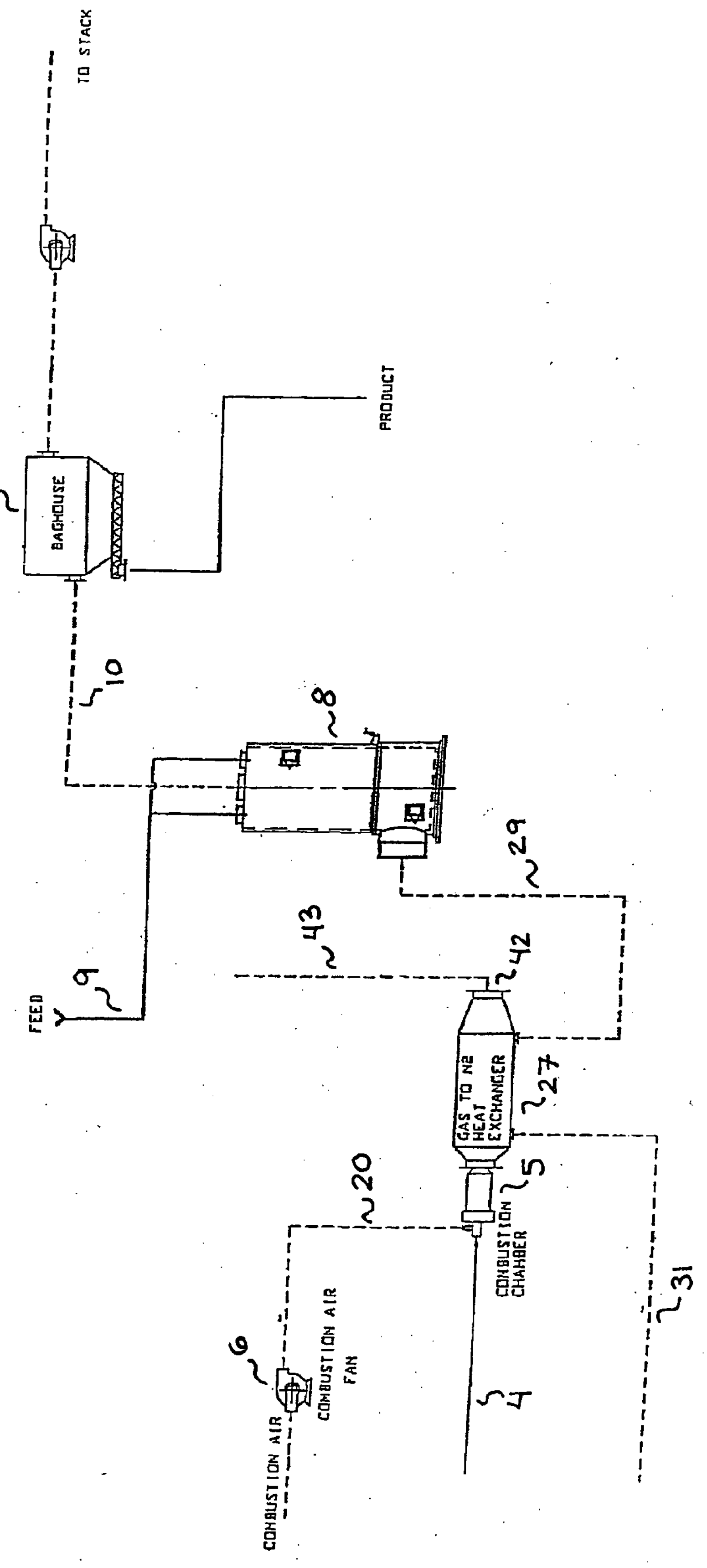
TO STACK
PRODUCT
BAGHOUSE
11
10
8
FEED
9
43
42
29
GAS TO N2 HEAT EXCHANGER
27
5
20
COMBUSTION CHAMBER
COMBUSTION AIR FAN
6
COMBUSTION AIR
4
31

FIGURE 4

METHOD FOR DRYING COPPER SULFIDE CONCENTRATES

FIELD OF THE INVENTION

[0001] This invention relates to the drying of copper concentrates in a gas suspension or fluid bed dryer. In one aspect, this invention relates to a process for the drying of copper concentrate that is both energy efficient and that reduces the possibility of concentrate combustion in the dryer.

BACKGROUND OF THE INVENTION

[0002] Present copper production from sulfide ores almost universally involves mining porphyry deposits composed mostly of chalcopyrite (Cu.FeS2). Raw ore is crushed and ground suitable for floatation concentration in which different materials are separated by agitating a pulverized mixture of the materials with water, oil, and chemicals. Differential wetting of the particles suspended during flotation causes unwetted particles to be carried by air bubbles to the surface for collection to produce a beneficiated ore containing about 25% copper and approximately equal portions of copper, iron, and sulfur. The concentrate is dewatered mechanically and subsequently dried to less than about 0.5% moisture by weight and preferably less than about 0.2% moisture by weight, in a direct fired dryer. However, at temperatures above 260° C. and in the presence of oxygen the sulfide concentrates will combust. Combustion in the dryer is undesirable and results in unsafe conditions and downtime. In order to stay below the ignition temperature of sulfide ores, significant amounts of excess air must be introduced into the gas heating means such as a hot gas generator that is upstream from the dryer. Ironically, this excess air invariably serves to provide oxygen for sulfide concentrate combustion.

[0003] Dried concentrate and suitable fluxes are introduced to smelters/converters where the iron and sulfur is oxidized and the iron combines with the flux agents. The sulfur is released as sulfur dioxide gas. Traditionally, the concentrated ore is processed in a primary smelting reactor, such as an oxygen/flash smelter; to produce a copper sulfide-iron sulfide matte, up to 60 percent copper. The matte is oxidized in a converter to convert the iron sulfides to iron oxides, which separate out in a slag, and to reduce the copper sulfide to blister copper, which contains at least 98.5 percent copper. Current technology combines the converting step with the proceeding smelting step. Fire refining of blister copper then removes most of the oxygen and other impurities, leaving a product at least 99.5 percent pure, which is cast into anodes. Finally, most anode copper is electrolytically refined, usually to a purity of at least 99.95 percent.

[0004] In order to generate high sulfur dioxide gas concentrations and reduce off gas volumes, present practice is to use oxygen enrichment in the smelter/convert processes.

[0005] While there are many processes known and in use today in the production of copper, uniformly they all require the use of substantial amounts of oxygen requiring the utilization of oxygen producing plants. The oxygen plants required to support the oxygen enrichment generate substantial waste nitrogen. It would be both environmentally and economically efficient to utilize the waste nitrogen produced in the oxygen plant in the copper process.

SUMMARY OF THE INVENTION

[0006] According to this invention, waste nitrogen produced in an oxygen plant is preheated to temperatures suitable to dry copper concentrates in a gas suspension or fluid bed dryer.

[0007] In a first embodiment of the invention waste nitrogen from the oxygen plant is directed to a hot gas generator, in the presence of heated ambient air, thereby substantially reducing the oxygen content of the preheated ambient air in the hot gas generator. The oxygen depleted ambient air and the heated nitrogen gas are directed to a fluid bed or gas suspension device where they are mixed with and dry wet concentrate. The dried concentrate is carried out of the device with the spent nitrogen and ambient air and is collected for further treatment.

[0008] In another embodiment of the invention removing the oxygen source eliminates the possibility of concentrate combustion in the dryer. Waste nitrogen from the oxygen plant is directed to an air to gas heat exchanger. A hot gas generator fires the heat exchanger. However, the ambient air from the hot gas generator used as the heat transfer medium is directed to atmosphere and not into the drying device. Nitrogen preheated to significantly above the concentrate ignition temperature (260° C.) is directed to a fluid bed or gas suspension device where it is mixed with and dries incoming wet concentrate. The dried concentrate is carried out of the device with the spent nitrogen and collected for further treatment.

[0009] In a third embodiment of the invention there is a method for drying copper sulfide concentrates in gas suspension and fluid bed dryers utilizing controlled sulfide ore oxidation. In this embodiment the risk of concentrate combustion is reduced by controlling the amount of oxygen utilized in the dryer. Waste nitrogen and a controlled amount of oxygen from the oxygen plant is directed to a heat exchanger and preheated to temperatures sufficient to dry the copper concentrates. The preheated oxygen and nitrogen gases are directed to a fluid bed or gas suspension device where they are mixed with incoming wet concentrate. The reactor temperature is maintained above the concentrate combustion temperature and the sulfide is allowed to oxidize in a controlled fashion—thus providing the dehydration energy without supplemental fuel firing. The dried concentrate is carried out of the device with the spent drying gasses, passes through the economizer and collected for further treatment.

[0010] The present process has the benefit of significantly reducing the combustion risk when drying sulfide concentrates in a fluid bed or gas suspension dryer. The present process also benefits from lower equipment costs due to smaller gas handling requirements and significant power savings by using waste nitrogen.

[0011] Various embodiments of the invention are further described in the drawings in which like numerals are employed to designate like parts. Although items of equipment, such as valves, fittings, holding tanks, pipes, and the like, have been omitted so as to simplify the description, those skilled in the art will recognize that such conventional equipment can be employed as desired.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a schematic flow diagram of a prior art process presented for comparative purposes.

[0013] FIG. **2** is a schematic flow diagram of a first embodiment of this invention.

[0014] FIG. **3** is a schematic flow diagram of another embodiment of this invention.

[0015] FIG. **4** is a schematic flow diagram of a third embodiment of this invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] It should be understood at the outset that identical reference numbers on the various drawing sheets refer to identical elements of the invention. It should also be understood that the following description is intended to completely describe the invention and to explain the best mode of practicing the invention known to the inventors but is not intended to be limiting in interpretation of the scope of the claims. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating principles of the invention.

[0017] Any conventional process can prepare the copper concentrates used in the practice of this invention, most preferably a flotation process, and such concentrates typically contain between about 10 and 50 percent by weight copper. The concentrates contain other metals, e.g. iron, lead, bismuth, arsenic, molybdenum, one or more precious metals. etc., that are associated with the copper in the ore deposit, and these metals, as well as the copper, are present in the concentrate principally as sulfides. The concentrate is typically in particulate form, typically with an average particle size less than about 65 U.S. mesh.

[0018] Oxidative-type smelting furnaces are also of two basic designs, bath and flash, the oxygen for which is provided by oxygen plants that generate waste nitrogen gas.

[0019] The copper concentrate is fed to the smelting furnace in conventional fashion. If the furnace is a flash smelting furnace, then the concentrate is mixed with flux and optionally recycled converter slag and/or slag concentrate (all of appropriate size), and the mix is then dried and fed (e.g. blown) into the furnace with oxygen or oxygen-enriched air.

[0020] FIG. **1** illustrates a prior art process improved upon by the present invention. Hot gas generator **5** is fired with ambient air (appx. 15°) from fan **6** via conduit **20** and a suitable fuel (e.g. no. 2 fuel oil) via conduit **4**. In order to stay below the ignition temperature of sulfide ores, significant amounts of excess ambient air is introduced into heated gas generator **5**, and such preheated air is then directed from heated gas generator **5** via conduit **7** into a drying chamber means which as depicted is a fluid bed dryer **8** (it is understood that, for example, a gas suspension dryer can be utilized instead of the fluid bed dryer), into which wet concentrate feed at approximately 10% moisture content by weight is also introduced via conduit **9** (on large diameter fluid bed dryers, two feed points **9***a* and **9***b* are typically utilized to promote a uniform feed distribution, which will serve to reduce local ore overheating in the bed and the resultant fire potential). The wet concentrate will fall by gravity into an inert bed within the fluid bed dryer **8**, which acts to break up agglomerates into their natural particle size. The finely divided concentrate is dried by the incoming hot gases and thereafter carried out of the fluid bed dryer with spent drying gases via conduit **10** to gas solid separator **11**, in this case a baghouse. The separated dried concentrate exits separator **11** via conduit **12**, where it is sent to the smelter/converted (not shown) for further processing, with the separated air going to stack via conduits **13** and fan **14**. As a further example (and the following elements are not shown in FIG. **1**), dried copper concentrate may be transferred by any conventional means from a storage area to concentrate hoppers for blending with slag or slag concentrate and flux which are held in separate hoppers. The flux (typically metallurgical grade silica, i.e. silicon dioxide) may be acquired from any convenient source, and the slag is typically a blend of converting furnace slag and smelting furnace slag concentrate (the latter a product of flotation to increase its copper content). All are sized and blended for optimum operation of the smelting furnace. The respective amounts of concentrate, flux and slag/slag concentrate in the smelting furnace feed will vary with, among other things, the nature of the concentrate.

[0021] FIG. **2** depicts a method according to the invention for drying copper sulfide concentrates in gas suspension or fluid bed dryers in which the risk of concentrate combustion is essentially eliminated by removing the most of the oxygen from the drying process. Waste nitrogen from the oxygen plant (not shown) is directed to the hot gas generator **5** via conduit **31** along with ambient air via fan **6** and conduit **20** and a suitable fuel via conduit **4**. This waste nitrogen is used to replace most of the ambient air supplied to gas generator **5**.

[0022] The use of nitrogen gas, plus the reduced use of ambient air from which much of the oxygen is depleted it reaction with the fuel to support combustion within hot gas generator **5**, substantially reduces the oxygen content in the heated gas mixture that leaves the hot gas generator **5** via conduit **25** and are directed into fluid bed dryer **8** in which they are utilized to dry the copper concentrate. The dried concentrate product is carried out of the fluid bed device with the spent nitrogen and ambient air via conduit **26**, directed through the gas solid separator **11** and the separated concentrate is collected for the smelter/converter step.

[0023] FIG. **3** illustrates a method for drying copper sulfide concentrates utilizing controlled sulfide ore oxidation. This embodiment reduces the risk of concentrate combustion by controlling the oxygen into the dryer. Waste nitrogen and a controlled amount of oxygen from the oxygen plant (not shown) is directed via, respectively, conduits **51** and **52** to a gas to N2 heat exchanger **27** and the heated oxygen/nitrogen mixture is then directed to dryer means **8** which in the depicted embodiment is a fluid bed dryer, via conduit **54**. Prior to entering the fluid bed dryer the oxygen/nitrogen mixture is optionally mixed with heated ambient air in conduit **53** and thereafter with incoming concentrate in dryer **8**. The amount of oxygen delivered into the drying chamber is insufficient to support the combustion of the concentrate at its normal combustion temperature. The temperature of fluid bed drier **8** is maintained above the concentrate combustion temperature to thereby allow the sulfide to oxidize in a controlled fashion via the careful introduction of oxygen—thus providing the dehydration energy with out supplemental fuel firing. When utilizing waste nitrogen in this fashion the inlet oxygen concentration in fluid bed dryer **8** can be less than 0.5% by volume which allows for a higher inlet temperature—approximately 315° C. compared to the approximately 280° C. utilized in conventional systems. The concentrate is carried out of dryer **8** with the spent drying gasses via conduit **55**, optionally passes through heat exchanger **27** and thereafter passes through the gas solid separator **11** and collected for further treatment. When gas solids separator **11** is a baghouse, nitrogen gas can be optionally utilized to clean the bags, such as by being directed into the bags via conduit **35**. Optionally, heat exchanger **27** can be directly in line with heated gas generator **5** in the manner depicted in FIG. **4**.

[0024] FIG. **4** depicts a method for safely drying copper sulfide concentrates in gas suspension or fluid bed dryers in which the inlet gas temperatures of the dryer are above the ignition point of the copper concentrate. In the depicted embodiment the possibility of concentrate combustion is essentially eliminated by removing the oxygen source. Waste nitrogen from the oxygen plant (not shown) is directed to an air to gas heat exchanger **27** via conduit **31**. Heat exchanger **27** is fired by hot gas generator **5** with which it is directly in line and into which gas generator ambient air is directed via combustion air fan **6**; however the heated ambient air from the generator **5** is directed to atmosphere via outlet **42** and conduit **43** and not into the drying device **8**. Nitrogen preheated significantly above (e.g., from about 300° C. to about 325° C.) the concentrate ignition temperature is directed to a fluid bed (or gas suspension) dryer **8** where it is mixed with incoming wet concentrate. The concentrate is carried out of the device with the spent nitrogen and collected for further treatment.

[0025] The fluid bed and gas suspension dryers suitable for use in the present invention are of the type well known in the art.

[0026] Although this invention has been described in detail by reference to the drawings, this detail is for illustration only, and it is not to be construed as a limitation upon the invention as described in the appended claims.

What is claimed is:

1. A process for drying copper sulfide concentrates in preparation for smelting the dried copper concentrates in an oxygen enriched environment, the oxygen for which is supplied by an oxygen plant that generates waste nitrogen gas, the process comprising:

A. introducing copper concentrates into a drying chamber;

B. directing waste nitrogen gas from the oxygen plant to a heat treatment means for heating the nitrogen gas to temperatures suitable to dry the copper concentrates;

C. introducing the heated nitrogen gas into the drying chamber to thereby dry the copper concentrates to a moisture content suitable for a smelter; and

D. recovering the dried copper concentrates.

2. The process of claim **1** wherein the drying chamber is a fluid bed dryer.

3. The process of claim **1** wherein the drying chamber is a gas suspension dryer.

4. The process of claim **1** wherein the concentrate is dried in the drying chamber in the absence of oxygen.

5. The process of claim **4** wherein the nitrogen gas is heated to significantly above the copper concentrate ignition temperature.

6. The process of claim **5** wherein the nitrogen gas is heated to temperatures of from about 300° C. to about 325° C.

7. The process of claim **1** wherein the heat treatment means is a hot gas generator into which there is introduced oxygen-containing ambient air, wherein in said hot gas generator at least some of the oxygen-containing ambient air reacts with a suitable fuel to support combustion to thereby heat the nitrogen gas and deplete the oxygen in the ambient air.

8. The process of claim **8** wherein the oxygen-depleted ambient air is introduced into the drying chamber along with the heated nitrogen gas.

9. The process of claim **1** wherein the heat treatment means is a heat exchanger into which there is also delivered, from the oxygen plant, a predetermined amount of oxygen gas for heating, after which the heated oxygen gas is delivered to the drying chamber along with the heated nitrogen gas.

10. The process of claim **9** the heated nitrogen gas and oxygen gas are mixed with heated ambient air prior to being delivered to the drying chamber.

11. The process of claim **9** wherein the amount of oxygen gas delivered into the drying chamber is insufficient to support the combustion of the concentrate at its normal combustion temperature.

12. The process of claim **11** wherein the temperature in the drying chamber is maintained above the combustion temperature for the concentrate to thereby permit the sulfides in the concentrate to oxidize in a controlled fashion.

13. The process of claim **9** wherein the dried concentrate is entrained in a heated oxygen and nitrogen gas mixture that is directed to the heat exchanger and thereafter to a gas solids separator.

14. A process for drying copper sulfide concentrates produced by a floatation process comprising:

A. introducing copper concentrates into a drying chamber;

B. directing nitrogen gas heated to temperatures suitable to dry the copper concentrates into the drying chamber to thereby dry the copper concentrates to a moisture content suitable for a smelter; and

C. recovering the dried copper concentrates.

15. The process of claim **14** wherein the drying chamber is a fluid bed dryer.

16. The process of claim **14** further comprising delivering heated oxygen gas into the drying chamber in an amount insufficient to support the combustion of the concentrate at its normal combustion temperature.

17. The process of claim **16** wherein the temperature in the drying chamber is maintained above the combustion temperature for the concentrate to thereby permit the sulfides in the concentrate to oxidize in a controlled fashion.

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