Patented Oct. 13, 1925. 1,556,822

UNITED STATES PATENT OFFICE.

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MULTIPLE-ROAST CHLORIDIZING PROCESS.

No Drawing. Application filed April 18, 1922. Serial No. 555,360.

To all whom it may concern:

Be it known that I, OSCAR B. HOFSTRAND, a citizen of the United States, and a resident of Salt Lake City, in the county of Salt Lake and State of Utah, have discovered a certain new and useful Multiple-Roast Chloridizing Process, of which the following forms a full, clear, and exact specification, such as will enable others skilled in the art to which it appertains to carry out the same in practice.

This discovery relates to a multiple-roast chloridizing process for the extraction of values from metalliferous ores and the like. The process is characterized by a series of successive roasting stages, and its principal objects are:—

First. To bring about an increased extraction of values from certain ores which contain substances that ordinarily interfere with the efficient application to those ores, of the chlorination process as commonly practised.

Second. To achieve a high percentage of extraction with the machinery and apparatus now in use.

Third. To provide a process which shall be simple, economical and efficient.

Fourth. To provide a process which may be practised by the ordinary mill organization without the necessity of employing specially trained, expert talent.

In attaining the objects outlined above, the ore to be treated is given two or more roasts, each roast being applied to the ore in approximately the same manner as in the ordinary chlorination process where the ore is given only one chloridizing roast, and the practice of which is well known. By the roasts additional to the first one, there is accomplished an increased extraction of values, from those ores for which this process is designed, to a degree that is never obtainable by a single roast.

A typical method of practicing the well known process which has been in use for many years, will be described first. Briefly, the ore to be treated, is crushed to pass a screen of about four mesh, after which the ore is stored in a suitable bin. A second ore which is selected with regard to a pre-determined content of so-called "fire-sulphur", the nature of which will presently be described, is similarly crushed, and stored in a separate bin. In a third bin is stored common salt which usually comes to the mill in large lumps but is crushed to a suitable size before being placed in the bin. Slack coal may be stored in a fourth bin, but of course requires no special grinding. These bins are located in what is known as the "mixing room", and each bin may be provided with a gate and an adjustable feeding device which latter may be regulated to discharge onto a conveyor, the proper proportion of each of the substances named. The conveyor may be any one of several different kinds, though what is known as a "belt-conveyor" is usually preferred.

Different ores require to be mixed with different amounts of the other substances, the usual proportions being about as follows: Salt 6 to 8%, sulphide ore sufficient to give 2 to 3% sulphur, coal 1 to 2%. The conveyor carries these ingredients to an elevator, and the latter lifts the mixture to a screen of about 6 to 8 mesh. The undersize goes through the screen while the oversize is returned to the crushing room to be re-crushed and again brought to the screen.

During the conveying, screening and re-crushing operations, the ingredients are thoroughly mixed with each other and the comparatively uniform mixture discharged from the screen as "undersize", drops into a bin which serves the roasting furnace. As the ore drops into the bin, water is added to the extent of 5 to 7%. The moistened mixture is now ready for the furnace which ordinarily may be of various designs, but the one which has so far been found most satisfactory for chloridizing purposes generally and also in the present process, is known as the "Holt-Dern" chloridizing furnace. As soon as one charge of ore is completely roasted, the

lower part of the charge is dropped through the grate, the upper and hottest part of the charge being left upon the grates. A fresh charge of ore is then dumped on the fire, air under pressure is supplied below the grates and is forced upward through the charge of ore until all the ore on the grates is roasted to the required degree.

After the chloridizing roast is completed, the ore is dumped into leaching vats, where a solution of common salt is allowed to percolate through the roasted ore until all the chloridized values have gone into solution. The pregnant solution is then removed from the tanks and is precipitated to remove the values. Silver may be precipitated on copper, and copper on iron; while the lead may be precipitated by a current of electricity, or on sponge iron. The tailings from the brine leaching operation may be cyanided to recover such a part of the gold as has not been recovered by the former treatment.

When an oxid or sulphid ore is subjected to a chloridizing roast as outlined above, followed by a subsequent treatment such as cyanide, hypo-sulphite, neutral or acid brine-leaching, it has been found that a content of calcium carbonate or magnesium carbonate in the ore, interferes greatly with the recovery of the metals, especially with silver. It is for this class of ores that my improved process is rendered especially valuable. In carrying out this improved process, the ore, after coming from the chloridizing furnace, following the first roast, is conveyed back to the mixing room where it is mixed with a fresh quantity of salt and sulphur, or sulphur-bearing ore, and the roasting operation as above described, is repeated. Sometimes three or more roasts may be required, the ore for each additional roast being mixed with a fresh quantity of salt and sulphur, or sulphur-bearing ore, as described. After the final roasting, the resulting mass is brought into solution and precipitated in the usual manner.

As an example illustrating the advantages of the present process over the ordinary chlorination process, its application to ores high in calcium and magnesium carbonates, may be mentioned. First, it should be understood that on an ore free from calcium and magnesium carbonates, a single chloridizing roast shows a recovery of gold and silver of 70% and 90% respectively. In a single chloridizing roast on an ore high in calcium or magnesium carbonates, the recovery of gold and silver is only 65% and 70% respectively, and therefore, such treatment is unprofitable. With the same ore, however, using the double or multiple chloridizing roast, as practiced in the present process, the recovery is found to be approximately 83% of the gold and 90% of the silver. A double or multiple roast is beneficial over a single roast in that the mixture of coal and sulphur can be proportioned to give different temperatures during successive roasts. This will also permit a wider variation in the amount of air supplied to the furnace.

The sulphur required in a chloridizing roast, had best be in the form of what may be termed "fire sulphur", that is, sulphur in combination as pyrite or chalco-pyrite. The nature of sulphur in this form is, that when once it is ignited, the combustion will continue without the application of heat from an external source.

When subjecting ores to a chloridizing roast, the two different classes to which attention has already been called, must be considered. One class of ores is characterized by having a gangue of quartz and the like, while the second class of ores is distinguished by a gangue of limestone, talc, spar or by minerals containing magnesia; in fact, most substances containing CO_2 might be included.

The gangue of the first mentioned class of ores may be said to be wholly inactive or inert, so far as having any effect on the chloridizing roast is concerned. Not so, however, is the gangue of the second kind, for on the contrary, this kind may be said to be highly active and therefore plays an important part by its effect on the action of the chloridizing roast. The consequence of this activity is the taking up by the gangue, of a considerable part of the metal sulphides and sodium chloride during the first roast, as for instance, $Ca(Mg)CO_3$ is converted into $Ca(Mg)O$, $Ca(Mg)SO_4$ and $Ca(Mg)Cl_2$, thus depriving the valuable metallic contents of the ore, of the full benefit of the chloridizing roast, and resulting in a lessened extraction of the metals as previously mentioned herein.

In considering the advantages of the present process, it is well to bear in mind some of the disadvantages of single-roast chloridizing with relation to ores of the second kind. In a single roast, it is impossible to add to the ore being treated, a sufficient percentage of sulphur to secure the maximum extraction of the values, owing to the fact that the quantity of sulphur required, would give too high a temperature for chloridizing, thereby causing a sintering of the ore, with the consequent evil of "freezing up" the furnace, thus compelling the shutting down of the furnace for a period of several days after each time it is used. This would cause the loss of valuable time, besides the loss of the values contained in the sintered ore. Such procedure would, of course, be absurd and prohibitive.

Now, to give directly, some of the advan-

tages of the multiple-roast chloridizing, it may be stated that in this process, the amount of sulphur necessary to secure the full extraction of the values, can be divided between successive roasts, so that in each separate roast there will not be sulphur enough to cause an excessive temperature, therefore eliminating any danger of sintering, and leaving the charge after the final roasting, in a soft or loose condition so that it can be easily and quickly discharged from the furnace, and permitting the uninterrupted operation of the furnace.

Sulphur in combination with lead, as galena and the like, can be used in a chloridizing roast, providing sufficient coal, or other combustible substance, is added to the charge to maintain the combustion and thus decompose the lead sulphid.

When the ore to be treated, contains large quantities of sulphur, a part, or all, of the sulphur may be removed by giving the ore an oxidizing roast previous to the chloridizing roast. In such cases, certain quantities of the same high sulphur ore may be used with the previously oxidized ore to furnish the necessary sulphur for the chloridizing roasts.

In many cases coal does not have to be added to the furnace charge at all, as the entire combustion can be sustained by the sulphur content alone.

The present process is not concerned with particular ingredients, per se, nor with the percentages of the ingredients, per se, its sole purpose being to apply a series of successive chloridizing roasts, and in distributing the total chloridizing effect through the different roasts in such proportions as may be deemed most satisfactory in each particular instance.

Many different modifications of the chlorination process have been evolved for treating different ores, and for operating under different conditions, but all the different methods heretofore employed, are based on giving the ore only one chloridizing roast. It is immaterial to my discovery, just which modification is used, so long as better results are obtained by employing more than one chloridizing roast.

A partial or incomplete chloridization may be said to take place in each roasting stage, with the completion thereof in the final roasting stage.

Between the succeeding roasting stages the ore may be cooled more or less.

It will be understood, that wherever the term "salt" is used herein, sodium chloride (NaCl) is meant.

While the description of the present process as embodied in this specification, is based on various experiments and on numerous tests under actual working conditions, I wish it understood that more or less theory, advanced by myself during the progress of the work, is involved in my explanation, and it is not my purpose thereby to define or limit my rights as to the beneficial effects which are obtainable by the use of this discovery.

Furthermore, the various details as to the practice of my improved process, may, or may not, be given in the preferred forms in the above recitation, and also, the preferred forms may be varied from time to time, depending upon the circumstances and conditions governing, and governed by, the development of this discovery and the arts to which it is incident, so the interested inquirer is directed to interpret the scope of this discovery, from the claims, in which its spirit is broadly generalized.

Having fully described my discovery, what I claim is:

1. In a multiple-roast chloridizing process for ore, the method of chloridizing the values in the said ore, consisting in subjecting the ore to a plurality of successive chloridizing roasts, the said ore being cooled between succeeding roasts.

2. In a multiple-roast chloridizing process for ores, the method of roasting the said ores in a series of succeeding stages, suitable quantities of salt, sulphur and coal being mixed with the said ores at each of the said roasting stages.

3. In a multiple-roast chloridizing process for ores containing valuable metals with objectionable metallic carbonates and the like, the method consisting in mixing the said ores with salt, sulphur and coal, then roasting the entire mixture in the presence of atmospheric air; mixing the resulting mass with a fresh quantity of salt, sulphur and coal, roasting the new mixture in the presence of air, then repeating the fresh mixing of the specified ingredients with the product of a previous roasting, and again roasting each new mixture, until the desired degree of extraction of the valuable contents of the said ores has been reached.

4. A multiple-roast chloridizing process for ores, the said process being characterized by an initial roasting stage wherein the furnace charge comprises a mixture of ore, salt, sulphur and coal; and one or more subsequent roasting stages, wherein the furnace charge of each stage comprises a mixture of the product of a previous roasting stage with fresh quantities of salt, sulphur and coal; the amount of sulphur employed in each stage being proportioned to produce, on combustion, a temperature below that which would cause a sintering of the corresponding furnace charge.

5. A multiple-roast chloridizing process for ores, the said process being practiced in two or more roasting stages, each stage embracing the mixing of the ores or the product of a previous roasting stage, as the case

may be, with suitable quantities of salt, sulphur and coal, and then roasting the mixture in the presence of air.

6. A multiple-roast chloridizing process for ores, the said process being practiced in two or more roasting stages, each stage embracing the mixing of the ores or the product of a previous roasting stage, as the case may be, with suitable quantities of salt, sulphur and coal, and then roasting the mixture in the presence of air, the quantity of sulphur employed in each of the said stages being so proportioned that on combustion of the sulphur, a sintering of the mixture shall not take place.

In testimony whereof, I sign my name hereto.

OSCAR B. HOFSTRAND.