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METHOD OF REFINING NICKEL-COPPER MATTE

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This invention relates to the treatment of converter matte for the separation of nickel from other metals associated therewith in such matte.

In practically every large deposit of nickel sulphide yet discovered the metal occurs in association with sulphides of iron and copper, together with small quantities of gold, silver, platinum, palladium, iridium, rhodium, ruthenium and osmium. In the usual metallurgical practice all of these metals except the iron (a part of which is oxidized) are concentrated into a matte of low or medium grade, which is subsequently blown in converters for the elimination of the remaining iron and much of the sulphur. The converter matte produced, containing about 80% of nickel-plus-copper and practically all of the precious metals originally in the ore, is then ready to be refined.

Several methods of refining this converter matte are now in commercial use. In every case the principal step is a partial separation of the nickel and copper, most of the copper being removed with a small amount of the nickel, while a considerable proportion of the copper remains with the greater part of the nickel. The fact that only a partial separation is obtained by these methods leads to great complexity in subsequent operations, and may even result in the loss of the greater part of the precious metals, since these are more difficult to separate from the nickel than from the copper. It is therefore of great commercial importance that a simpler method of separation should be made available, not only to reduce the cost of separation to a minimum but also to secure a complete recovery of the precious metals.

The object of this invention is thus to provide a simple, economical method for the separation of nickel and the complete recovery of copper and the precious metals from nickel-copper mattes.

The invention is based in part upon the fact that the sulphide of nickel is soluble in acids, while those of copper, silver, gold and all the metals of the platinum group are insoluble. This fact is well known in analytical chemistry and numerous investigators have attempted to take advantage of it to dissolve nickel sulphide from matte and leave the other sulphides in an insoluble residue. There are thus many patents in the prior art disclosing processes based upon this general principle. Such processes, however, have not attained the desired commercial success, owing, it is thought, to the fact that the nickel in ordinary converter matte dissolves slowly and incompletely.

It is an object of this invention to increase the rate of solution of the nickel sulphide constituent of the matte in acids, and the extent to which this constituent of the matte will dissolve. This is accomplished by two steps, used singly or in combination in a refining process, which is simple and efficient.

The invention comprises rapidly cooling the matte and retaining in the matte an appreciable amount of iron sulphide. Each of these steps is effective in increasing the rate of solution of the nickel sulphide constituent of the matte and at the same time the extent to which this constituent will go into solution.

The comparative slowness with which the nickel sulphide of ordinary converter matte dissolves is probably due to the crystalline character of the matte, the formation of crystals either preventing access of acid to a part of the nickel-sulphide constituent or presenting to the attack of the acid such a resistant molecular aggregate that rapid and complete solution is impossible, or both of these forces act together. In accordance with this invention the growth of crystals is prevented by rapidly cooling the matte. The nickel is thereby rendered so soluble in acid that there may be obtained, within a reasonable time, and in one simple operation, a separation of 98–100% of the nickel from 99.9–100% of the copper and precious metals, the sulphides of which are insoluble. This reaction takes place at ordinary temperatures, but more rapidly at 80–100° C. The most convenient method of cooling matte rapidly is by granulating it in water, but any method of rapid cooling which will give to the matte the desired characteristic may be employed.

The principal constituent of an ordinary

nickel-copper matte, such as is produced in a blast or reverberatory furnace, is iron sulphide. The oxidation of this iron sulphide is the primary object of the converting process, ordinary practice being to carry the elimination of the iron as far as possible without the oxidation of much nickel, which, if oxidized, at once passes into the slag. Complete elimination of the iron is very difficult, and in the usual practice 0.2–0.8% of iron remains in the matte poured from the converter. It has, however, been found that if a substantial amount of iron-sulphide is retained in the matte, and the latter is treated with acid, the solution of the iron-sulphide gives freer access of the acid to the less soluble nickel-sulphide constitutent of the matte and thus increases the rate of solution of the latter. Thus in accordance with this invention the converter blow is terminated at such time as will leave in the matte an appreciable amount of iron sulphide. Good results have been obtained in increasing the rate of solution of the nickel-sulphide by retaining in the matte 2–10% of iron sulphide. Obviously, the iron content of the matte must not be indefinitely increased, since the iron has ordinarily to be separated from the nickel in a subsequent operation.

A further advantage obtained by discontinuing the converter blow before substantially all the iron is oxidized is that less nickel is oxidized and the percentage of this metal in the slag is thereby greatly reduced.

In the preferred embodiment of this invention therefore the maximum rate and completeness, consistent with low cost of operation, are obtained by retaining in the matte a substantial amount of iron sulphide and by rapidly cooling the matte from the molten condition. The amount of iron sulphide retained in the matte is substantially within the limits above mentioned.

When sulphuric acid is used to dissolve the nickel from matte, as will ordinarily be the case, the supply of acid may be replenished by oxidation of the hydrogen sulphide liberated in the reaction, nearly as much acid being thus formed as is consumed in the solution of the nickel. The manufacture of acid may be carried out by any of the ordinary methods, since hydrogen sulphide burns readily to sulphur dioxide, which is the base of the usual methods of manufacturing sulphuric acid. If sulphuric acid is not desired, the hydrogen sulphide may be partially oxidized by air with the formation of water vapour and elemental sulphur, the latter forming a valuable by-product.

In dissolving nickel from matte advantage may be taken of the principle of counter-current flow. Thus in practice fresh matte may be treated with a slightly acid solution of nickel sulphate formed by previous treatment of nearly exhausted matte with moderately concentrated acid. In this way it is commercially feasible not only to secure substantially complete extraction of the nickel from the matte in a short time, but also to produce, if desired, a neutral solution of nickel sulphate. Moreover, if any of the copper sulphide in the nearly exhausted matte should go into solution through prolonged treatment with acid, it will be immediately and completely precipitated upon contact with fresh matte, due to the liberation of hydrogen sulphide by the action of acid upon undecomposed matte.

The neutral or slightly acid nickel sulphate solution produced by this process contains most of the iron which was present in the converter matte, and it is usually desirable to remove this. This can be readily accomplished by the addition to the solution of finely divided calcium carbonate, sodium carbonate, nickel carbonate, nickel hydroxide or other suitable precipitant, followed by agitation with air to oxidize the iron to the ferric condition. Manganese dioxide or other oxidizing agents may be used instead of air, if preferred.

The purified nickel sulphate solution can be utilized in a variety of ways. Simple evaporation and crystallization will produce nickel sulphate crystals, which may be marketed as such. If the double sulphate of nickel and ammonium be desired this can be obtained by the addition of ammonium sulphate, followed by crystallization. The strength of the nickel sulphate solution may be controlled by varying the strength of the dissolving acid. If, therefore, it is intended to crystallize out the salts, a moderately strong acid may be used, the object being to produce a solution practically saturated with nickel sulphate, so that a minimum of evaporation will be required.

These uses do not ordinarily absorb a very large tonnage of nickel, however, and to secure a larger market the nickel may be reduced to the metallic condition. This can be effected by first heating the crystals to 800–900 deg. C., when they are rapidly decomposed to nickel oxide, sulphuric anhydride and water vapor. The sulphuric anhydride will normally be absorbed in water, or recovered by simple cooling with the water vapor, the quantity of acid thus formed being substantially equal to that used in the solution of the nickel. Since the hydrogen sulphide evolved in the reaction may also have been converted into sulphuric acid this process can produce sulphuric acid as a by-product, the quantity of such acid being normally about equal to the tonnage of the matte treated. The nickel oxide formed by the decomposition of the sulphate is readily reduced to metal by heating it with any suitable form of reducing agent.

If it be desired to produce electrolytic

nickel from the nickel sulphate solution, with regeneration of the sulphuric acid, this may be accomplished by electrolysis with insoluble anodes. In ordinary solutions of nickel sulphate, even though they be but slightly acid, electrolysis with insoluble anodes is ineffective in depositing nickel in commercial quantity. I have found, however, that by the production of a solution of nickel sulphate in the above-described way, the current efficiency is greatly increased, due to the high purity of the solution, and nickel can be deposited from it until the acid content of the solution rises fairly high, the spent electrolyte being used to dissolve more nickel from the matte.

The residue of insoluble sulphides is best treated for the recovery of the contained copper by first reducing it to the molten condition and then blowing the matte formed to metal in a converter. When such copper is refined electrolytically, either with or without preliminary furnace refining, high-grade copper is obtained, and the residue from the anodes contains, in a highly concentrated form, all the precious metals associated with the nickel and copper. If the copper anodes contain a very small percentage of nickel, as will usually be the case, this may be allowed to accumulate in the solution until the nickel content is high, when portions of the electrolyte may be periodically removed for the separation of nickel sulphate, as in ordinary refining practice. In this way all the commercially valuable metals originally present in the ore may be readily recovered in a marketable form, when the matte is treated in accordance with this invention.

What I claim is:

1. A method of refining nickel-copper matte, which comprises rapidly cooling the matte to increase the rate and completeness of solution in acid of the nickel sulphide constituent thereof and leaching the matte with acid to dissolve the nickel sulphide.

2. A method of refining nickel-copper matte, which comprises retaining in the matte a substantial amount of iron sulphide and rapidly cooling the matte to increase the rate and completeness of solution in acid of the nickel sulphide constituent thereof, and leaching the matte with acid.

3. A method of refining nickel-copper matte, which comprises treating the matte in a converter to reduce the iron sulphide content thereof to 2–10%, rapidly cooling the matte and granulating the same by treatment with water, and leaching the granulated matte with acid to dissolve the nickel.

4. In the process of refining nickel-copper matte the step which comprises increasing the rate of solution of the nickel constituent of said matte in acid by retaining in the matte a substantial amount of iron sulphide.

5. In the process of refining nickel-copper matte the step which comprises increasing the effectiveness of acid as a solvent of the nickel constituent of the matte by rapidly cooling the matte as herein described.

6. A method of refining nickel-copper matte which comprises blowing air into the matte in a converter, increasing the effectiveness of acid as a solvent of the nickel sulphide content of the matte by discontinuing the converter treatment when there is a substantial amount of iron sulphide in the matte and rapidly cooling the matte, then leaching said matte in acid to dissolve the nickel sulphide as herein described.

In testimony whereof I have affixed my signature.

FRANK EUGENE LATHE.