(54) Title: RECOVERY OF NICKEL AND COPPER FROM SULPHIDE CONCENTRATES BY BIOLEACHING

(57) Abstract: A process for recovering nickel and copper from a concentrate which includes the steps of subjecting the concentrate to a treatment phase to produce a first leach solution which contains predominantly copper and a second leach solution which contains predominantly nickel, subjecting the first leach solution to a process for copper recovery which includes a solvent extraction step to produce a raffinate which is high in sulphuric acid, recycling at least a portion of the raffinate to the aforementioned treatment phase and subjecting the second leach solution to a process for nickel recovery.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
BACKGROUND OF THE INVENTION

This invention relates to the recovery of nickel and copper from concentrates which contain minerals of both metals.

The specification of South African patent No. 98/2549 describes a process for the recovery of copper which includes the following steps:

(a) biologically oxidising copper sulphate concentrate in slurry form to dissolve copper as soluble copper sulphate;

(b) subjecting the slurry to solid/liquid separation to produce a solution with a high copper concentration;

(c) treating the solution with a solvent extraction reagent so that copper ions are exchanged by the reagent for hydrogen ions to produce a raffinate which is high in sulphuric acid and low in copper sulphate;

(d) stripping the solvent extraction reagent with a sulphuric acid solution;

(e) electrowinning copper from the sulphuric acid solution; and

(f) using at least a portion of the raffinate from step (c) in step (a).

An important feature of this process is the application of biologically assisted leaching of copper concentrates with the use of a portion of the raffinate produced by solvent extraction to satisfy the demand for acid in the leaching step.
SUMMARY OF THE INVENTION

The present invention is concerned with the recovery of nickel and copper from a concentrate which contains a substantial amount of nickel.

The invention provides a process for recovering nickel and copper from a concentrate which includes the steps of:

(a) subjecting the concentrate to a treatment phase to produce:

(1) a first leach solution which contains predominantly copper and

(2) a second leach solution which contains predominantly nickel;

(b) subjecting the first leach solution to a process for copper recovery which includes a solvent extraction step to produce a raffinate which is high in sulphuric acid;

(c) recycling at least a portion of the raffinate to the treatment phase of step (a), and

(d) subjecting the second leach solution to a process for nickel recovery.

In one form of the invention the treatment phase of step (a) includes the steps of:

(e) separating the concentrate by flotation into a first concentrate which is substantially a copper concentrate and a second concentrate which is substantially a nickel concentrate;

(f) biologically oxidising the first concentrate to produce the said first leach solution, and
(g) biologically oxidising the second concentrate to produce the said second leach solution.

With this form of the invention the raffinate produced in step (b) is recycled at least to the oxidation step (f). The raffinate may, depending on the conditions, also be recycled to the oxidation step (g).

The process of step (d) may include a step of solvent extraction to extract copper from the second leach solution before nickel is recovered from the second leach solution.

Preferably step (f) is carried out at an elevated temperature, eg. from 65°C to 80°C, so that thermophilic archaea such as Sulfolobus are active and chalcopyrite is thereby dissolved by biological oxidation.

In a second form of the invention the treatment phase of step (a) includes the steps of subjecting the concentrate in series:

(h) to a first biological oxidation step to dissolve nickel as nickel sulphate in the said second leach liquor, and

(i) to a second biological oxidation step to dissolve copper as copper sulphate in the said first leach liquor.

In step (h) the oxidation may be conducted at a moderate temperature, of the order of from 40°C to 45°C, to dissolve pentlandite as nickel sulphate, with use being made of mesophilic, or moderate thermotolerant, bacteria.
In step (i) the oxidation may be conducted at a relatively elevated temperature, of the order of 70°C to 80°C, to dissolve chalcopryte as copper sulphate, with use being made of thermotolerant or thermophilic bacteria or archaea, such as the type *Sulfolobus*.

In each case solid/liquid separation is used to obtain a solution.

5 The nickel sulphate may be subjected to solvent extraction for copper, before nickel recovery takes place.

The copper sulphate is subjected to solvent extraction for copper, thereby producing the said raffinate which is high in sulphuric acid and which is recycled to at least one of the oxidation steps.

10 **BRIEF DESCRIPTION OF THE DRAWINGS**

The invention is further described by way of examples with reference to the accompanying drawings. Figures 1 and 2, which respectively illustrate different embodiments of the invention.

**DESCRIPTION OF PREFERRED EMBODIMENTS**

15 Figure 1 of the accompanying drawings illustrates a process for the recovery of nickel and copper from a concentrate 10 which contains minerals of both metals. The concentrate 10 is subjected to a flotation process 12 which separates the concentrate into a first concentrate 14 which is substantially a copper concentrate, with some nickel usually in the form of pentlandite, and into a second concentrate 16 which is substantially a nickel concentrate, mainly pentlandite, with some copper present usually in the form of chalcopryte.
The copper concentrate 14 is subjected to a biological oxidation and leaching step 18 and then to a solid/liquid separation step 20. This is followed by a solvent extraction phase 22 which produces copper 24 and a raffinate 26 which has a high acid content.

In the method of the aforementioned patent at least a portion of the raffinate is recycled to the biological oxidation step. In the present invention though substantially all of the raffinate 26 is recycled, at least a portion thereof going to the biological oxidation and leaching step 18.

The nickel concentrate 16 is subjected to a biological oxidation and leaching step 28. Acid is obtained from the remaining portion of the recycled raffinate 26. The step 28 is followed by a solid/liquid separation step 30 and the copper in solution is recovered by a solvent extraction step 32.

An alkali 34 such as lime, limestone or ammonia is used to precipitate iron and some copper 36, and the resulting solution is then treated for nickel recovery in a step 38. Again alkali 40 is added to the solution, at this stage, because ion exchange and solvent extraction for nickel requires a high pH.

After the nickel recovery the solution has no free acid and the solution is not recycled to the biological oxidation stages. It may be recycled for solution balance or it may be used as wash water in the solid/liquid separation steps 20 and 30.

A significant advantage of this process is that a substantial saving in sulphuric acid is achieved by recycling the raffinate to the stages 18 and 28.
The biological oxidation steps 18 and 26 are preferably conducted at elevated temperatures of the order of from 65°C to 80°C so that thermophilic archaea such as *Sulfolobus* are active and chalcopyrite is dissolved.

Figure 2 illustrates a second embodiment of the process of the invention.

A concentrate 50 which contains minerals of nickel and copper is subjected to two biological oxidation steps 52 and 54 which are carried out sequentially i.e. in series, thereby producing a leach solution which contains most of the nickel and a small quantity of copper, and another leach solution which contains most of the copper and a small quantity of nickel.

In the step 52 biological oxidation is conducted using mesophiles at a moderate temperature of the order of 40°C to 45°C, or moderate thermophiles at a temperature of 45°C to 55°C. Nickel in the form of pentlandite is dissolved as nickel. Some copper is also dissolved. The leach solution is subjected to a solid/liquid separation step 56 and the resulting solution is treated with a solvent (58) for extracting copper 60. Alkali 62, in the form of lime, limestone or ammonia is then added to the solution to precipitate copper and iron (64) and the resulting solution is subjected to nickel recovery 66 after alkali 68 is added. After the nickel 70 has been extracted the remaining solution 72 is not suitable for recycling for acid content but, as has been described hereinbefore, can be recycled for solution balance.

The second biological oxidation step 54 is carried out at an elevated temperature of the order of 70°C to 85°C using thermophiles. Copper in the form of chalcopyrite is dissolved to give a leach solution of copper sulphate with a small quantity of nickel
sulphate. The solution is subjected to a solid/liquid separation step 74 and thereafter copper 76 is recovered by means of a solvent extraction phase 78. The resulting raffinate 80 is high in sulphuric acid and, as is the case with the Figure 1 embodiment, is recycled to one or both of the oxidation steps 52 and 54. Thus the acid is recovered.

In both embodiments the sulphuric acid in the raffinate can be recovered by recycling the raffinate to the biological oxidation and leaching step. This results in a significant cost saving.
CLAIMS

1. A process for recovering nickel and copper from a concentrate which includes the steps of:

(a) subjecting the concentrate to a treatment phase to produce:

5 (1) a first leach solution which contains predominantly copper and

(2) a second leach solution which contains predominantly nickel;

(b) subjecting the first leach solution to a process for copper recovery which includes a solvent extraction step to produce a raffinate which is high in sulphuric acid;

(c) recycling at least a portion of the raffinate to the treatment phase of step (a), and

10 (d) subjecting the second leach solution to a process for nickel recovery.

2. A process according to claim 1 wherein the treatment phase of step (a) includes the steps of:

(e) separating the concentrate by flotation into a first concentrate which is substantially a copper concentrate and a second concentrate which is substantially a nickel concentrate;

15 (f) biologically oxidising the first concentrate to produce the said first leach solution, and

(g) biologically oxidising the second concentrate to produce the said second leach solution.
3. A process according to claim 2 wherein the raffinate produced in step (b) is recycled at least to the oxidation step (f).

4. A process according to claim 3 wherein the raffinate is also recycled to the oxidation step (g).

5. A process according to claim 2, 3 or 4 wherein step (f) is carried out at an elevated temperature so that thermophilic archaea are active and chalcopryte is thereby dissolved by biological oxidation.

6. A process according to claim 5 wherein the said elevated temperature is from 65°C to 80°C.

7. A process according to any one of claims 1 to 5 wherein the process of step (d) includes a step of solvent extraction to extract copper from the second leach solution before nickel is recovered from the second leach solution.

8. A process according to claim 1 wherein the treatment phase of step (a) includes the steps of subjecting the concentrate in series:

   (h) to a first biological oxidation step to dissolve nickel as nickel sulphate in the said second leach liquor, and

   (i) to a second biological oxidation step to dissolve copper as copper sulphate in the said first leach liquor.

9. A process according to claim 8 wherein in step (h) the oxidation is conducted at a moderate temperature to dissolve pentlandite as nickel sulphate, with use being made of mesophilic, or moderate thermotolerant, bacteria.
10. A process according to claim 9 wherein the said moderate temperature is from 40°C to 45°C.

11. A process according to claim 8, 9 or 10 wherein in step (i) the oxidation is conducted at a relatively elevated temperature to dissolve chalcopyrite as copper sulphate, with use being made of thermotolerant or thermophilic bacteria or archaea.

12. A process according to claim 11 wherein the said relatively elevated temperature is from 70°C to 80°C.

13. A process according to any one of claims 8 to 12 wherein the nickel sulphate is subjected to solvent extraction for copper, before nickel recovery takes place.

14. A process according to any one of claims 8 to 13 wherein the copper sulphate is subjected to solvent extraction for copper, thereby producing the said raffinate which is high in sulphuric acid and which is recycled.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

| IPC  | C22B3/18 | C22B15/00 | C22B23/00 |

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)

| IPC  | 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 practical, search terms used)

WPI Data, EPO-Internal, COMPENDEX, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**X** Further documents are listed in the continuation of box C.

**X** Patent family members are listed in annex.

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Date of the actual completion of the international search

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