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(54) Title: HYDROMETALLURGICAL PROCESS OF NICKEL LATERITE ORE

(57) Abrégé/Abstract:
A hydrometallurgical process for a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization-step, and a final neutralization step, which comprises at least one step selected from the following steps (B) and (C): (B) separation and recovery, by a physical separation method, of hematite particles in a leaching residue slurry produced from the solid-liquid separation step; or (C) subjecting a neutralization precipitate slurry produced from the neutralization step to the final neutralization step separately from a leaching residue produced from the solid-liquid separation step.
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Abstract

A hydrometallurgical process for a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, which comprises at least one step selected from the following steps (B) and (C): (B) separation and recovery, by a physical separation method, of hematite particles in a leaching residue slurry produced from the solid-liquid separation step; or (C) subjecting a neutralization precipitate slurry produced from the neutralization step to the final neutralization step separately from a leaching residue produced from the solid-liquid separation step.
SPECIFICATION

HYDROMETALLURGICAL PROCESS OF NICKEL LATERITE ORE

This is a divisional application of Canadian Patent Application No. 2,678,724, filed September 15, 2009. It should be understood that the expression "the present invention" or the like used in this specification encompasses not only the subject matter of this divisional application but that of the parent application also.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a hydrometallurgical process of a nickel laterite ore, and in more detail, the present invention relates to a hydrometallurgical process of a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, which process enables to prevent wear of equipment such as a pipeline, a pump, caused by an ore slurry produced from the ore treatment step, and enhance durability thereof, and also reduce an amount of a final neutralization residue produced from the final neutralization step, and thus to solve the problem of prevention of cost and environmental risk by decrease in volume of a tailing dam for storing a leaching residue, neutralization precipitate etc. to be subjected to waste disposal, as well as separate and recover impurity components which may be utilized effectively by resource recycling.

DESCRIPTION OF THE PRIOR ART

In recent years, with ever increasing oligopoly of mining right in mineral resources such as coal, iron, copper, nickel, cobalt, chromium, manganese, raw material cost in metal smelting has increased to a large degree.

Therefore, also in metal
smelting, as a means for cost reduction, technological development has been carried out so as to use low content raw materials, which have not been an object conventionally, because of disadvantage in view of cost. For example, in nickel refining, also thanks to development of a material having excellent corrosion resistance under high temperature and high pressure, a hydrometallurgical process for smelting, based on a High Pressure Acid Leach is noticed, where a nickel laterite ore is subjected to acid leaching with sulfuric acid under high pressure.

This High Pressure Acid Leach, different from a pyrometallurgical refining, which is a conventional general process for smelting a nickel laterite ore, does not include dry steps such as a reduction step, a drying step, and is thus advantageous in view of energy cost, therefore evaluated as promising technology as a process for smelting a low content nickel laterite ore. Accordingly, various proposals have been made on enhancement of leaching rate of nickel and cobalt, for purification of leach solution, or reduction of reagents usage, majoring in a leaching step under high temperature and high pressure, so as to enhance the completeness as a smelting process.

Incidentally, as a process where leaching under high temperature and high pressure is utilized, for example, in recovering the metals from an oxide ore containing the valuable metals such as nickel, cobalt, manganese, a method for recovering the valuable metals from an oxide ore composed of
the following steps (a) to (c), has been proposed (for example, refer to Patent Reference 1).

a step (a): obtaining normal pressure leach solution and normal pressure leaching residue, by subjecting laterite ore, converted to slurry in advance, to normal pressure leaching under acid condition of sulfuric acid, using a high pressure leach solution obtained in a step (b).

a step (b): obtaining a high pressure leach solution by subjecting the normal pressure leaching residue obtained in the step (a), to a reaction with sulfuric acid under oxidation atmosphere under high temperature and high pressure.

a step (c): recovering nickel and cobalt in the leach solution as sulfides by the addition of a neutralizing agent into the normal pressure leach solution obtained in the step (a) for neutralization, and the subsequent addition of an alkali sulfide compound.

In this method, by carrying out the two-stage leaching, normal pressure leaching of an oxide slurry (the step (a)), and then High Pressure Acid Leaching of the normal pressure leaching residue (the step (b)), nickel leaching rate from the ore can be enhanced, and at the same time, load of the neutralization step (the step (c)) can be reduced by neutralization of an excess acid contained in the leach solution of the High Pressure Acid Leaching with the alkali component contained in the normal pressure leaching residue. However, because of the two-stage leaching, it had problems of increase in cost and time caused by increase in equipment number, and requirement of cost for treatment of a large quantity of a thin solution generating in
washing of the leaching residue.

In order to solve these problems, a method composed of the following steps (1) to (4), has been proposed, as other process for utilization of leaching under high temperature and high pressure (for example, refer to Patent Literature 2).

(1) a leaching step: forming a leaching slurry by the addition of sulfuric acid to a nickel laterite ore, which was converted to slurry in advance, and by stirring treatment at a temperature of 220 to 280 °C.

(2) a solid-liquid separation step: separation to a leach solution containing nickel and cobalt, and a leaching residue, by washing of the above-described leaching slurry using a multi-stage thickener.

(3) a neutralization step: forming a neutralization precipitate containing ferric iron, by adjustment of pH to equal to or lower than 4 using calcium carbonate, under prevention of oxidation of the above-described leach solution, so as to separate to the neutralization precipitate slurry and a mother liquor for nickel and cobalt recovery, and

(4) a sulfurization step: blowing hydrogen sulfide gas into the above-described mother liquor for nickel recovery, so as to generate a sulfide containing a nickel and a cobalt, and separate it from a barren liquor.

Here, explanation will be given on outline of a practical plant based on the above method (Patent Literature 2) with reference to a drawing. Figure 2 is a process chart of smelting showing one example of a practical plant based on the
hydrometallurgical process of a nickel laterite ore (Patent Literature 2).

In Figure 2, firstly a nickel laterite ore 8 is mixed with water in an ore treatment step 1, and then removal of foreign material and adjustment of ore particle size of the ore are carried out to form an ore slurry 9. Then, in a leaching step 2, the ore slurry 9 is subjected to High Pressure Acid Leach with sulfuric acid to form leaching slurry 10. The leaching slurry 10 is subjected to a solid-liquid separation step 3 for multi-stage washing, and then separated to a leach solution 11 containing a nickel and a cobalt, and a leaching residue slurry 12. The leach solution 11 is subjected to a neutralization step 4 and separated to a neutralization precipitate slurry containing a ferric iron hydroxide 13, and a mother liquor for nickel recovery (1) 14. The mother liquor (1) 14 is subjected to a zinc removal step 5, where a sulfurizing agent is added, so as to separate to a zinc sulfide precipitate 15 containing a zinc sulfide, and a mother liquor for nickel recovery (2) 16. Then, the mother liquor (2) 16 is subjected to a sulfurization step 6 and separated to a mixed sulfide 17 containing a nickel and a cobalt, and a barren liquor 18 removed nickel etc. It should be noted that, the barren liquor 18 is used as washing water of the leaching residue in the solid-liquid separation step 3.

Lastly, the leaching residue slurry 12 is subjected to a final neutralization step 7 together with the excess barren liquor 18 for neutralization treatment, and a final neutralization residue 19 is stored in a tailing dam 20.
As features of this method, there are included that consumption amount of the neutralizing agent and amount of the precipitate in the neutralization step can be reduced, by multi-stage washing of the leaching slurry in the solid-liquid separation step; solid-liquid separation characteristics can be improved due to increasing ability of true density of the leaching residue; and still more a process can be simplified by carrying out the leaching step only by leaching under high temperature and high pressure, and it is said to have advantage relative to the above-described method (Patent Literature 1). Still more, using a barren liquor as a washing solution to be used in the solid-liquid separation step, nickel adhered onto the leaching residue can be recovered with leaching, by utilization of remaining sulfuric acid, and it is said to be capable of using repeatedly the water effectively and efficiently. Still more, by sending the neutralization precipitate slurry to the solid-liquid separation step, nickel loss can be reduced, therefore it is said to be more advantageous.

However, the practical plant by this method had the following problems:

(1) prevention of equipment wear: a nickel laterite ore is carried between the steps as slurry, which significantly accelerates the wear of an equipment material, in particular, repair frequency increases for equipment such as a pipeline, a pump in the leaching step, and it gave a serious cause for increase in maintenance cost, and decrease in plant operation rate. That is, chromite contained in the nickel laterite ore is particularly hard, and is a component extremely to accelerate
the wear of the pipeline, the pump, and the like, in a hydrometallurgical process for smelting accompanying with carrying of slurry, therefore, it is desirable to remove it from a raw material ore to be treated in the leaching step.

(2) increase in solid rate of an ore slurry: in general, the higher solid rate of slurry of a nickel laterite ore provides the less solution amount to be handled, which enables to simplify equipment such as a pipeline, a tank, therefore, it is preferable that the ore slurry is concentrated to such a degree as there is no trouble in liquid sending or the like by a pump, or such a degree as there is no generation of pipeline clogging, however, there was limitation accompanying with sedimentation property of the ore slurry.

(3) decrease in content of impurity elements of the ore slurry: in the leaching step, because impurity elements such as magnesium, aluminum contained in the ore slurry give a big influence on consumption of sulfuric acid, content of these impurity elements is preferably to be as low as possible.

(4) decrease in amount of final neutralization residue: the leaching residue obtained in the solid-liquid separation step is combined together with an excess barren liquor produced from the sulfurization step, and is made harmless by the neutralization step where lime stone slurry or slaked lime slurry is added. The final neutralization residue produced in this final neutralization treatment step (hereafter may be referred to as a final neutralization step), is stored in a
tailing dam. However, because the final neutralization residue contains impurity components such as hematite, chromite, a silica mineral, magnesium silicate ore in the leaching residue, as well as gypsum formed by neutralization treatment, there was a large cost burden for construction of the tailing dam and maintenance management thereof. Therefore, effective material recycling of impurity components such as hematite, chromite, a silica mineral, magnesium silicate ore in the above-described leaching residue is expected. For example, chromite is expected to be utilized as a raw material to produce ferrochromium to be used as an addition element of stainless steel. However, in production of ferrochromium, recovery thereof is desired, in view of treatment efficiency or cost, as a concentrate with a chromium content of, for example, equal to or higher than 5% by mass. In addition, hematite is expected to be utilized as a raw material of steel and stainless-steel. However, because many components other than hematite are contained in the above-described leaching residue, separation from these components is desired. In particular, sulfur has a generation problem of sulfurous acid gas in a steel making step, therefore it is desired to contain sulfur as low as possible. Upper limit value of allowable sulfur content depends on a plant, which receives as a raw material of iron and steel, however, in general, it is said necessary to lower the content to equal to or lower than about 2 to 3% by mass.

(5) repeated treatment of a neutralization precipitate slurry: As described above, treatment of the neutralization precipitate slurry in the solid-liquid separation step is effective to
enhance nickel recovery, however, iron hydroxide in the neutralization precipitate is also re-dissolved here, which results in increase in consumption amount of a neutralizing reagent, as well as increase in amount of the leach residue. Therefore it is desirable that the neutralization precipitate to be recycled to the solid-liquid separation step is as low as possible.

From the above circumstances, it has been required to solve the above problems in a practical plant using the hydrometallurgical process for smelting based on the above High Pressure Acid Leach. Still more, in order to solve the above problems effectively and economically, effective separation and recovery of impurity components contained in an ore or the leaching residue is an effective means, and also effective utilization of these impurity components by material recycling has also been required.


SUMMARY OF THE INVENTION

The present invention relates to a hydrometallurgical process of a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach including an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization
step, which process enables to prevent wear of equipment such as a pipeline, a pump, caused by an ore slurry produced from the ore treatment step, and thus enhance durability thereof, simplify the equipment of the ore treatment step by increase in solid rate of the ore slurry, and also reduce amount of a final neutralization residue produced from the final neutralization step, and thus to solve the problem of prevention of cost and environmental risk thanks to decrease in volume of a tailing dam for storing a leaching residue, neutralization precipitate slurry or the like to be subjected to waste disposal, as well as separate and recover impurity components which may be utilized effectively by resource recycling.

The present invention relates to a hydrometallurgical process for smelting to recover nickel and cobalt from a nickel laterite ore by a High Pressure Acid Leach including an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, and found, as a result, that it is effective, as a means to solve the above problems, to carry out at least one step selected from steps: step of (A) for separating and recovering, by a specific method, the particles containing a silica mineral, chromite or a magnesium silicate ore in ore slurry produced from the ore treatment step; step of (B) for separating and recovering, by a specific method, the hematite particles in leaching residue slurry produced from the solid-liquid separation step; or step (C) for subjecting a neutralization precipitate slurry,
produced from the neutralization step, to the final neutralization treatment separately, and have thus completed the present invention.

That is, according to a first aspect of the present invention, there is provided a hydrometallurgical process of a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach including an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, characterized by including at least one step selected from the following steps (A) to (C): (A) separation and recovery, by a physical separation method, of particles containing at least one kind selected from a silica mineral, chromite or a magnesium silicate ore in ore slurry produced from the above-described ore treatment step; (B) separation and recovery, by a physical separation method, of hematite particles in leaching residue slurry produced from the above-described solid-liquid separation step; and (C) step for subjecting a neutralization precipitate slurry, produced from the above-described neutralization step, to the final neutralization treatment separately from the leaching residue produced from the above-described solid-liquid separation step.

In addition, according to a second aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the first aspect, characterized in that, in step of the above-described (C), zinc
sulfide precipitate slurry produced from the above-described zinc removal step is subjected to the final neutralization treatment together with the above-described neutralization precipitate slurry at the same time.

In addition, according to a third aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the first or the second aspect, characterized in that:
the above-described ore treatment step is a step for forming the ore slurry by carrying out removal of foreign material and adjustment of ore particle size of a raw material ore mined;
the above-described leaching step is a step for forming a leaching slurry composed of leaching residue and leach solution, by the addition of sulfuric acid to the ore slurry and by carrying out the stirring treatment under high temperature and high pressure;
the above-described solid-liquid separation step is a step for obtaining leach solution containing nickel and cobalt, and a leaching residue slurry, by multi-stage washing of the leaching slurry;
the above-described neutralization step is a step for forming neutralization precipitate slurry containing ferric iron, and a mother liquor for nickel recovery, by the addition of calcium carbonate into the leach solution;
the above-described zinc removal step is a step for forming zinc sulfide precipitate slurry and a mother liquor for nickel and cobalt recovery, by blowing hydrogen sulfide gas into the mother liquor;
the above-described sulfurization step is a step for forming a mixed sulfide containing nickel and cobalt and, a barren liquor by blowing hydrogen sulfide into the mother liquor for nickel and cobalt recovery; and
the above-described final neutralization step is a step for obtaining a final neutralization residue, by the addition of an excess barren liquor into the leaching residue slurry, and adjusting pH to about 8 to 9.

In addition, according to a forth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the third aspect, characterized in that, in the above-described ore treatment step, ore particle size adjustment is subjected to sieve treatment at a particle size of equal to or smaller than 2 mm.

In addition, according to a fifth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to any one of the first to the forth aspects, characterized in that, in step of the above-described (A), the above-described ore slurry is subjected to a physical separation method by sieve classification or centrifugal classification, wherein the coarse particle part classified is recovered as a concentrate of silica mineral, chromite or a magnesium silicate ore.

In addition, according to a sixth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the fifth aspect,
characterized in that the above-described classification particle size is selected from a range of 20 to 850 μm.

In addition, according to a seventh aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the fifth aspect, characterized in that the above-described classification particle size is two particle sizes selected from a range of equal to or larger than 850 μm and a range of 20 to 850 μm, wherein firstly a coarse particle part classified at the particle size of the former range is recovered as a concentrate of a silica mineral or a magnesium silicate ore, and next a coarse particle part classified at the particle size of the latter range is recovered as a concentrate of chromite.

In addition, according to an eighth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to any one of the first to the forth aspects, characterized in that, in step of the above-described (B), the above-described leaching residue slurry or the final neutralization residue slurry containing it is subjected to a physical separation method by sieve classification or centrifugal classification, wherein the fine particle part classified is recovered as a concentrate of hematite.

In addition, according to a ninth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to the eighth aspect,
characterized in that the above-described classification particle size is selected from a range of 20 to 100 μm.

In addition, according to a tenth aspect of the present invention, there is provided the hydrometallurgical process of a nickel laterite ore according to any one of the first to the forth aspects, characterized in that, in step of the above-described (B), the above-described leaching residue slurry or the final neutralization residue slurry containing it is subjected to a physical separation method by magnetic separation, wherein a magnetized substance is recovered as a concentrate of hematite.

The hydrometallurgical process of a nickel laterite ore of the present invention is capable of solving or at least mitigating the above-described problems as follows, by adoption of steps of (A) to (C), in a hydrometallurgical process for smelting to recover nickel and cobalt from a nickel laterite ore by a High Pressure Acid Leach including an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, therefore, industrial value thereof is extremely high.

By adoption of the step of (A), it is possible to prevent the wear of equipment such as a pipeline, a pump caused by the ore slurry as well as increase solid rate of the slurry, by separation and recovery of particles containing a silica mineral, chromite and a magnesium silicate ore in ore slurry produced.
from the ore treatment step. Still more, by separation of these impurity components, amount of the final neutralization residue can be reduced owing to decrease in amount of the leaching residue, as well as reduction of contents of impurity elements, which influences largely on use amount of sulfuric acid, can be attained. Here, these impurity components, in particular, chromite can be utilized effectively.

In addition, by adoption of the step of (B), by separation and recovery of hematite in leaching residue slurry produced from the solid-liquid separation step, it is possible to reduce amount of a final neutralization residue produced from the final neutralization step, and thus prevent cost and environmental risk thanks to decrease in volume of a tailing dam for storing a leaching residue, neutralization precipitate or the like to be subjected to waste disposal, as well as separate and recover hematite which may be utilized effectively as iron resources.

In addition, by adoption of the step (C), by subjecting a neutralization precipitate slurry produced from the neutralization step to a separate neutralization treatment divided from the final neutralization step, amount of the final neutralization residue can be reduced, which is particularly advantageous in separation and recovery of hematite in the leaching residue.
Specific embodiments of the invention (parent application) are as follows:

[1] A hydrometallurgical process for a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step, a leaching step, a solid-liquid separation step, a neutralization step, a zinc removal step, a sulfurization step, and a final neutralization step, which comprises: step (A): (A) separation and recovery, by a physical separation method, of particles comprising at least one of a silica mineral, chromite or a magnesium silicate ore in an ore slurry produced from the ore treatment step.

[2] The hydrometallurgical process according to [1], wherein: the ore treatment step is a step for forming the ore slurry by removing foreign material and adjusting ore particle size of a mined raw material ore; the leaching step forms a leaching slurry composed of leaching residue and leach solution, by the addition of sulfuric acid to said ore slurry and by stirring treatment under high temperature and high pressure; the solid-liquid separation step gives a leach solution comprising nickel and cobalt, and a leaching residue slurry, by multi-stage washing of said leaching slurry; the neutralization step forms a neutralization precipitate slurry comprising ferric iron, and a mother liquor for nickel recovery, by the addition of calcium carbonate into said leach solution; the zinc removal step forms a zinc sulfide precipitate slurry, and a mother liquor for nickel and cobalt recovery, by blowing hydrogen sulfide gas into said mother liquor; the sulfurization step forms a mixed sulfide comprising nickel and cobalt, and a barren liquor, by blowing hydrogen
sulfide into said mother liquor for nickel and cobalt recovery; and the final neutralization step gives a final neutralization residue, by the addition of an excess barren liquor into said leaching residue slurry, and adjusting pH to about 8 to 9.

5 [3] The hydrometallurgical process according to [2], wherein the ore treatment step, ore particle size adjustment is subjected to a sieve treatment at a particle size of equal to or smaller than 2 mm.

[4] The hydrometallurgical process according to any one of [1] to [3], wherein step (A), the ore slurry is subjected to the physical separation method by sieve classification or centrifugal classification, wherein a coarse particle classified part is recovered as a concentrate of the silica mineral, chromite or the magnesium silicate ore.

15 [5] The hydrometallurgical process according to [4], wherein classified particle size is selected from a range of 20 to 850 μm.

[6] The hydrometallurgical process according to [4], wherein classified particle size is in two particle sizes selected from a range of equal to or larger than 850 μm and a range of 20 to 850 μm, wherein first a coarse particle part classified at the particle size of equal to or larger than 850 μm is recovered as a concentrate of the silica mineral or the magnesium silicate ore, and next a coarse particle part classified at the particle size of 20 to 850 μm is recovered as a concentrate of chromite.

Specific embodiments of the invention (this divisional application) are as follows:
A hydrometallurgical process for a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step for forming an ore slurry by removing foreign material and adjusting ore particle size of a mined raw material ore; a leaching step forms a leaching slurry composed of leaching residue and leach solution, by the addition of sulfuric acid to said ore slurry and by stirring treatment under high temperature and high pressure; a solid-liquid separation step which gives a leach solution comprising nickel and cobalt, and a leaching residue slurry, by multi-stage washing of said leaching slurry; a neutralization step which forms a neutralization precipitate slurry comprising ferric iron, and a mother liquor for nickel recovery, by the addition of calcium carbonate into said leach solution; a zinc removal step which forms a zinc sulfide precipitate slurry, and a mother liquor for nickel and cobalt recovery, by blowing hydrogen sulfide gas into said mother liquor; a sulfurization step which forms a mixed sulfide comprising nickel and cobalt, and a barren liquor, by blowing hydrogen sulfide into said mother liquor for nickel and cobalt recovery; and a final neutralization step which gives a final neutralization residue slurry, by the addition of an excess barren liquor into said leaching residue slurry, and adjusting pH to about 8 to 9, which neutralization step comprises the following step (B): (B) separation and recovery, by a physical separation method, of hematite particles from the leaching residue slurry produced from the solid-liquid separation step.

The hydrometallurgical process according to [1], wherein in the ore treatment step, ore particle size adjustment
is subjected to a sieve treatment at a particle size of equal to or smaller than 2 mm.

[3] The hydrometallurgical process according to any one of [1] and [2], wherein step (B), the leaching residue slurry or the final neutralization residue slurry comprising the leaching residue slurry is subject to the physical separation method by sieve classification or centrifugal classification, wherein the fine particle part classified is recovered as a concentrate of hematite.

[4] The hydrometallurgical process according to [3], wherein the classified particle size is selected from a range of 20 to 100 μm.

[5] The hydrometallurgical process according to any one of [1] and [2], wherein step (B), the leaching residue slurry or the final neutralization residue slurry comprising the leaching residue slurry is subjected to the physical separation method by magnetic separation, wherein a magnetized substance is recovered as a concentrate of hematite.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a process chart of smelting showing one example of embodiments according to the hydrometallurgical process of
a nickel laterite ore relevant to the present invention.

Figure 2 is a process chart of smelting showing one example of a practical plant based on the hydrometallurgical process of a nickel laterite ore (Patent Literature 2).

Figure 3 is a drawing for showing the relation between particle size and content of iron, chromium and silicon of the leaching residue.

Figure 4 is a drawing for showing the relation between particle size and distribution rate of iron, chromium and silicon of the leaching residue.

NOTATION
1 ore treatment step
2 leaching step
3 solid-liquid separation step
4 neutralization step
5 zinc removal step
6 sulfuration step
7 final neutralization step or final neutralization step (1)
8 nickel laterite ore
9 ore slurry
10 leaching slurry
11 leach solution
12 leaching residue slurry
13 neutralization precipitate slurry
14 mother liquor (1)
15 zinc sulfide precipitate
16 mother liquor (2)
17 mixed sulfide
18 barren liquor
19 final neutralization residue or final neutralization residue
(1)
20 tailing dam
21 step of (A)
22 chromite or the like
23 step of (B)
24 hematite precipitate
25 final neutralization step (2) (step (C))
26 final neutralization residue (2)

DETAILED DESCRIPTION OF THE INVENTION

The hydrometallurgical process of a nickel laterite ore
of the present invention is a hydrometallurgical process of a
nickel laterite ore to recover nickel and cobalt from the nickel
laterite ore by a High Pressure Acid Leach including an ore
treatment step, a leaching step, a solid-liquid separation step,
a neutralization step, a zinc removal step, a sulfurization step,
and a final neutralization step, characterized by including at
least one step selected from the following steps (A) to (C).
(A) separation and recovery, by a physical separation method,
of particles containing at least one kind selected from a silica
mineral, chromite or a magnesium silicate ore in ore slurry
produced from the above-described ore treatment step;
(B) separation and recovery, by a physical separation method,
of hematite particles in leaching residue slurry produced from
the above-described solid-liquid separation step; and
(C) step for subjecting a neutralization precipitate slurry,
produced from the above-described neutralization step, to the
final neutralization treatment separately from the leaching residue produced from the above-described solid-liquid separation step.

In the method of the present invention, it is important to include at least one step selected from the above-described steps (A) to (C), in order to solve the problems.

Here, by adoption of the step (A), it is possible to prevent the wear of equipment such as a pipeline, a pump caused by the ore slurry, as well as increase solid rate of the ore slurry, by separation and recovery of particles containing the silica mineral, chromite and the magnesium silicate ore in ore slurry produced from the above-described ore treatment step. That is, by separation of chromite or a magnesium silicate (magnesium silicate) ore having extremely high hardness, which is generally contained in a nickel laterite ore, wear can be prevented, as well as it is possible to eliminate one of the causes of obstructing increase in solid rate of ore slurry, by separation of low density cristobalite (amorphous silica) and viscous aggregated block (for example, montmorillonite: a hydrated silicate of iron and aluminum), which generally are included in the nickel laterite ore and give bad influence on sedimentation property. Still more, separation of these impurity components enables to reduce amount of final neutralization residue thanks to decrease in amount of the leaching residue, as well as attain reduction of content of impurity components, which largely influence on use amount of sulfuric acid. Incidentally, these impurity components, in particular, chromite can be utilized effectively. It should be
noted that because chromite is a valuable mineral containing a chromium of a component of stainless steel, it can be utilized as an effective resource, when it is separated and recovered. Here, in the use as a raw material in production of ferrochromium, which is used as an addition element in stainless steel production, in view of treatment efficiency or cost, separation is preferably at a chromium content of, for example, equal to or higher than 5% by mass.

In addition, by adoption of the step (B), by separation and recovery of hematite particles in leaching residue produced from the above-described solid-liquid separation step, it is possible to reduce amount of the final neutralization residue produced from the final neutralization step, and thus prevent cost and environmental risk thanks to decrease in volume of a tailing dam for storing the leaching residue, neutralization precipitate or the like to be subjected to waste disposal, as well as separate and recover hematite which may be utilized effectively as iron resource. That is, because iron in a nickel laterite ore is hydrolyzed at high temperature in the leaching step, and iron is contained in a hematite form in the final neutralization residue. However, because the final neutralization residue contains chromite, a magnesium silicate ore and the like in the leaching residue, as well as gypsum formed by neutralization treatment, iron content is as low as in the order of 30 to 50% by mass, therefore it was difficult to be utilized effectively, as it is, as a raw material in iron production or the like, where a content of generally equal to or higher than 60% by mass is said to be preferable, in
consideration of production efficiency or cost. This is because, sulfur, chromium, silicon or the like is a component giving influence on distribution of trace components into pig iron, quality of iron and steel products or the like, therefore it was required to prevent a content of these impurity components.

In addition, by adoption of the step of (C), by subjecting a neutralization precipitate slurry produced from the above-described neutralization step to a separate neutralization treatment divided from the final neutralization step, amount of the above-described final neutralization residue can be reduced, which is particularly advantageous in separation and recovery of hematite in the leaching residue. That is, in the solid-liquid separation step, treatment of the neutralization precipitate slurry, which had conventionally been repeated, increased consumption amount of a neutralizing agent.

Firstly, explanation will be given on embodiments of the hydrometallurgical process of a nickel laterite ore of the present invention, with reference to a drawing.

Figure 1 is a process chart of smelting showing one example of embodiments of the hydrometallurgical process of a nickel laterite ore relevant to the present invention.

In Figure 1, firstly a nickel laterite ore 8 is mixed with water in an ore treatment step 1, and then removal of foreign material and adjustment of ore particle size of the ore are carried out to form an ore slurry 9. In this step or after that, the ore slurry 9 is subjected to a newly added step 21 of (A)
for separation and recovery of a silica mineral, a magnesium silicate ore or chromite or the like 22. The ore slurry 9 is subjected to the leaching step 2. Here, the ore slurry 9 is charged into an autoclave or the like for leaching valuable components such as nickel, cobalt, with sulfuric acid, and forming a leaching slurry 10. The leaching slurry 10 is subjected to the solid-liquid separation step 3 using a multi-stage thickener or the like, for separation to a leach solution containing nickel and cobalt 11 and the leaching residue slurry 12.

Subsequently, the leach solution 11 is subjected to the neutralization step 4 for separation to the neutralization residue 13 containing mainly ferric iron hydroxide, and a mother liquor containing nickel (1) 14. The mother liquor (1) 14 is subjected to the zinc removal step 5, where a sulfurizing agent is added, for separation to a zinc sulfide precipitate 15 containing zinc sulfide, and a mother liquor (2) 16 for nickel recovery. Then, the mother liquor (2) 16 is subjected to the sulfurization step 6, where a sulfurizing agent is added, for separation to a mixed sulfide 17 containing nickel and cobalt, and a barren liquor 18. It should be noted that, the barren liquor 18 is used as washing water of the leaching residue in the solid-liquid separation step 3, and as washing water of the neutralization precipitate slurry 13 produced in the neutralization step 4.

Lastly, the leaching residue slurry 12 is subjected to a final neutralization step (1) 7 together with the excess barren
liquor 18 for neutralization treatment. In this step or after
that, the leaching residue slurry 12 is subjected to a newly
added step 23 of (B) for separation to the final neutralization
residue (1) 19 and the hematite precipitate 24. In addition,
the neutralization precipitate slurry 13 is subjected to the
final neutralization step (2) 25, which corresponds to a newly
added step (C), together with zinc sulfide precipitate 15. The
resulting final neutralization residue (2) 26 and a final
neutralization residue (1) 19 are stored in a tailing dam 20.

Explanation will be given below in still more detail on
each step.

(1) The ore treatment step and the step of (A)

The above ore treatment step is a step for forming the ore
slurry by carrying out the removal of foreign material and
adjustment of ore particle size. Here, the nickel laterite ore
is subjected to sieving with a wet sieve or the like, for
separation of a foreign material not dissoluble in the leaching
step, an ore having a particle size giving difficulty in pump
flow sending, or the like. Here, sieving particle size is
usually about 2 mm, preferably 1.4 mm, and an ore with a particle
size equal to or larger than this range is subjected to crushing
treatment. Slurry is formed by the ore, which passed this
crushing-sieving treatment, and then it is subjected to
concentration by sedimentation, for preparation of ore slurry
adjusted with solid concentration in the slurry (slurry
concentration). It should be noted that the slurry
concentration is usually adjusted at about 25 to 45% by mass.
The above nickel laterite ore is the mineral such as mainly a limonite ore and a saprolite ore. Nickel content of the above-described laterite ore is usually 0.8 to 2.5% by mass, and nickel is contained as a hydroxide or a hydrated magnesium silicate (magnesium silicate) ore. Iron content is 10 to 50% by mass, and iron is mainly in a trivalent hydroxide form (goethite), however, a part of divalent iron is contained in the hydrated magnesium silicate ore or the like. In addition, silicic acid component is contained in a silica mineral such as quartz, cristobalite (amorphous silica), and the hydrated magnesium silicate ore. In addition, most of chromium is contained as a chromite ore containing iron or magnesium. In addition, magnesium component is contained in the hydrated magnesium silicate ore, as well as in a magnesium silicate ore which contains little un-weathered and high hardness nickel. As described above, the silica mineral, the chromite ore and the magnesium silicate ore in the laterite ore are, what is called, gangue components containing little nickel.

Therefore, in an ore slurry produced from the above ore treatment step, there are contained cristobalite, which gives bad influence on sedimentation property generally in increasing solid concentration, chromite and the magnesium silicate ore, which give large influence on wear of equipment such as a pipeline, a pump, together with magnesium, which consumes sulfuric acid in the leaching step, and still more a magnesium silicate mineral having low nickel content.

Therefore, it is desirable that the silica mineral such as cristobalite, chromite and the magnesium silicate ore are
separated and recovered in advance in the ore treatment step from the ore slurry to be prepared in the ore treatment step.

Now, explanation will be given on a distribution state of each of the components in ore particles composing the ore slurry.

From EPMA observation of a nickel laterite ore, it is found that a part having high content of chromium, silicon and magnesium has high presence rate as a single phase independent from a part having high content of iron, and in many cases, it has a particle diameter of 20 to 1000 μm. This shows that an ore containing chromium, silicon and magnesium is contained, in a large quantity, in particles of equal to or larger than about 20 μm, and on the other hand, an ore containing nickel and iron is contained, in a large quantity, in particles of equal to or smaller than about 20 μm.

Therefore, for effective separation and recovery of the silica mineral, the chromite ore and the magnesium silicate ore from an ore slurry, it is important that the ore after removing a coarse block is converted to slurry, and a nickel laterite ore in this ore slurry is crushed so as to have suitable particle size, and suitable classification particle size is set. It should be noted that, the above-described crushing particle size is preferably equal to or smaller than 2 mm, more preferably equal to or smaller than 1.4 mm, although it is determined in consideration of original object in formation of the ore slurry, and property of the ore.

Examples of ore particle size distribution of the
above-described ore slurry, and content of each component in each particle size classification are shown in Table 1 and Table 2. It should be noted that, ores used in Table 1 and Table 2 are those having different ore deposit from where they are produced.

Table 1 shows one example of ore particle size distribution of the ore slurry obtained by crushing to a particle size of equal to or smaller than 2 mm, and content of each component in each particle size classification. From Table 1, it is understood that chromium, silicon, magnesium and the like are concentrated in each particle size classification of a coarse part of equal to or larger than 75 μm, and in particular, silicon, magnesium and the like are concentrated in each particle size classification of a coarse part of equal to or larger than 355 μm.

<table>
<thead>
<tr>
<th>Particle size (μm)</th>
<th>Distribution rate (% by mass)</th>
<th>Chemical composition (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fe</td>
</tr>
<tr>
<td>-2000 to +1400</td>
<td>0.9</td>
<td>36</td>
</tr>
<tr>
<td>-1400 to +850</td>
<td>1.8</td>
<td>37</td>
</tr>
<tr>
<td>-850 to +355</td>
<td>2.7</td>
<td>33</td>
</tr>
<tr>
<td>-355 to +75</td>
<td>5.3</td>
<td>42</td>
</tr>
<tr>
<td>-75</td>
<td>89.3</td>
<td>47</td>
</tr>
<tr>
<td>Average</td>
<td>100</td>
<td>45.7</td>
</tr>
</tbody>
</table>

In addition, Table 2 shows one example of ore particle size distribution of the ore slurry obtained by crushing to a particle size of equal to or smaller than 1.4 mm, and content of each
component in each particle size classification. From Table 2, it is understood that chromium, silicon, magnesium and the like are concentrated in each particle size classification of a coarse part of equal to or larger than 75 μm, and in particular, silicon, magnesium and the like are concentrated in each particle size classification of a coarse part of equal to or larger than 100 μm. In addition, in Table 3, average analysis values are shown, when each particle size classification in Table 2 is summed up every predetermined particle size range.

Table 2

<table>
<thead>
<tr>
<th>Particle size (μm)</th>
<th>Distribution rate (% by mass)</th>
<th>Chemical composition (% by mass)</th>
<th>Calculated value (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ni</td>
<td>Cr</td>
</tr>
<tr>
<td>-1400 to +1190</td>
<td>0.8</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>-1191 to +1000</td>
<td>0.1</td>
<td>0.6</td>
<td>5.6</td>
</tr>
<tr>
<td>-1000 to +850</td>
<td>0.2</td>
<td>0.5</td>
<td>11.2</td>
</tr>
<tr>
<td>-850 to +590</td>
<td>0.3</td>
<td>0.6</td>
<td>11.8</td>
</tr>
<tr>
<td>-590 to +425</td>
<td>0.5</td>
<td>0.4</td>
<td>19.3</td>
</tr>
<tr>
<td>-425 to +210</td>
<td>2.3</td>
<td>0.5</td>
<td>20.8</td>
</tr>
<tr>
<td>-200 to +100</td>
<td>2.7</td>
<td>0.4</td>
<td>20.2</td>
</tr>
<tr>
<td>-100 to +75</td>
<td>0.9</td>
<td>0.8</td>
<td>10.5</td>
</tr>
<tr>
<td>-75 to +37</td>
<td>8.8</td>
<td>1.1</td>
<td>4.2</td>
</tr>
<tr>
<td>-37</td>
<td>83.4</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Average</td>
<td>100</td>
<td>1.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Table 3

<table>
<thead>
<tr>
<th>Particle Size range (µm)</th>
<th>Amount (% by mass)</th>
<th>Ni (% by mass)</th>
<th>Cr (% by mass)</th>
<th>Fe (% by mass)</th>
<th>Si (% by mass)</th>
<th>Mg (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A +100 to -850</td>
<td>6</td>
<td>0.5</td>
<td>20.0</td>
<td>31.2</td>
<td>1.5</td>
<td>3.6</td>
</tr>
<tr>
<td>B +75 to -1000</td>
<td>7</td>
<td>0.5</td>
<td>18.5</td>
<td>33.0</td>
<td>1.5</td>
<td>3.4</td>
</tr>
<tr>
<td>C +37 to -850</td>
<td>16</td>
<td>0.8</td>
<td>10.5</td>
<td>42.5</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>D +37 to -1000</td>
<td>16</td>
<td>0.8</td>
<td>10.5</td>
<td>42.3</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>E -75</td>
<td>93</td>
<td>1.2</td>
<td>1.6</td>
<td>51.3</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>F -100</td>
<td>93</td>
<td>1.2</td>
<td>1.7</td>
<td>51.2</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>G +1000 to -1400</td>
<td>1</td>
<td>1.0</td>
<td>1.9</td>
<td>25.1</td>
<td>10.6</td>
<td>9.0</td>
</tr>
<tr>
<td>H +590 to -1400</td>
<td>1</td>
<td>0.8</td>
<td>5.3</td>
<td>26.7</td>
<td>8.6</td>
<td>7.5</td>
</tr>
</tbody>
</table>

From the above results, by utilization of the fact that particles containing chromium, silicon and magnesium in high content are coarser particles than particles containing iron in high content, the coarse particle part containing chromium, silicon and magnesium in high content, and a fine particle part containing nickel and iron in high content, are separated by a selection means such as a classification method. Here, the coarse particle part is discharged outside a system and purified in the separate step for recovering the chromium or the like as a resource.

In addition, in the above coarse particle part, because particles containing silicon and magnesium in high content, are distributed more in the coarse particle side than particles containing chromium in high content, it is possible to classify these by the predetermined particle size, and separate the particles containing silicon and magnesium in high content, so as to recover a concentrate with enhanced chromium content.
The step of the above (A) is a step for separation and recovery of at least one kind selected from a silica mineral, chromite or a magnesium silicate ore in ore slurry produced from the above ore treatment step. It should be noted that, the step of (A) may be carried out by being included in the above ore treatment step, or in the subsequent step thereto.

A method for step of the above (A) is not especially limited, and methods using various physical separation means for separation of a silica mineral, chromite or a magnesium silicate ore from the ore slurry, may be applied, and among these, physical separation methods by wet process such as sieving classification, sedimentation classification, centrifugal classification, which enables to separate and recover these all together from analysis of a distribution state of each component in the ore particles composing the ore slurry, are simple and convenient as a rough separation means, and thus preferable.

For example, there is adopted a method for subjecting the ore slurry to physical separation methods by sieving classification or centrifugal classification, for recovering thus classified coarse particle part as a concentrate of a silica mineral, chromite or a magnesium silicate ore. That is, in the above-classification, gangue components such as a silica mineral, chromite or a magnesium silicate ore are distributed in the classified coarse particle part, and on the other hand, goethite and a hydrated magnesium silicate ore containing a nickel are distributed in the classified fine particle part.
Classification particle size in the above classification is not especially limited, however, it is selected from a range of preferably 20 to 850 μm, more preferably 20 to 300 μm and particularly preferably 75 to 100 μm, in consideration of property of a raw material ore and nickel yield to the fine particle part, or the like. That is, lower limit of the classification point industrially applicable is about 20 μm, and further, the above-described classification particle size of below 20 μm provides insufficient concentration of a silica mineral, chromite or a magnesium silicate ore to the coarse particle part, as well as provides nickel loss in the ore slurry to be used in the leaching step. On the other hand, the above-described classification particle size of over 850 μm provides insufficient removal of a silica mineral, chromite or a magnesium silicate ore in the fine particle part.

In addition, in recovery of a concentrate with enhanced chromium content, from the above coarse particle part of a silica mineral, chromite or a magnesium silicate ore, two particle sizes selected from a range of equal to or larger than 850 μm and a range of 20 to 850 μm, are used, as the above-described classification particle size. Here, firstly, the coarse particle part classified by the particle size of the former range is recovered as a concentrate of a silica mineral or a magnesium silicate ore, and then the coarse particle part classified by the particle size of the latter range is recovered as a concentrate of chromite having reduced entrainment of a silica mineral or a magnesium silicate ore. Alternatively, also it can be carried out that firstly the coarse particle part classified
by the particle size of the latter range, is obtained, and then, the coarse particle part classified by the particle size of the former range is separated. That is, a concentrate of a silica mineral or a magnesium silicate ore is separated by selection of suitable particle size between 850 µm and a crushing particle size of the ore as classification particle size. On the other hand, a concentrate of chromium is efficiently separated by selection of suitable particle size, within a range of preferably 20 to 850 µm, more preferably 20 to 300 µm and particularly preferably 75 to 100 µm, as classification particle size.

(2) A leaching step

The above leaching step is a step for forming a leaching slurry composed of leaching residue and leach solution, by the addition of sulfuric acid to the ore slurry obtained in the above ore treatment step and the step of (A), and by carrying out stirring treatment under condition of a temperature of 220 to 280°C. In this step, a pre-heater, an autoclave and a flash tank are used as main equipment.

In the leaching step, leaching as sulfates such as nickel, cobalt, and fixation as hematite of leached iron sulfate are performed, by a leaching reaction and a high-temperature thermal hydrolysis reaction represented by the following formulae (1) to (5). However, because of incomplete proceeding of fixation of an iron ion, it is usual that nickel, cobalt or the like, as well as divalent and ferric iron ions are contained in a liquid part of the resulting leaching slurry.
[leach reaction]
MO+H₂SO₄ → MSO₄+H₂O --- (1)
(wherein, M represents Ni, Co, Fe, Zn, Cu, Mg, Cr, Mn or the like.)
2Fe(OH)₃+3H₂SO₄ → Fe₂(SO₄)₃+6H₂O --- (2)
FeO+H₂SO₄ → FeSO₄+H₂O --- (3)

[high-temperature thermal hydrolysis reaction]
2FeSO₄+H₂SO₄+1/2O₂ → Fe₂(SO₄)₃+H₂O --- (4)
Fe₂(SO₄)₃+3H₂O → Fe₂O₃+3H₂SO₄ --- (5)

Temperature to be used in the above leaching step is 220 to 280°C, and preferably 240 to 270°C. That is, iron is fixed as hematite, by performance of the reaction in this temperature range. In the temperature below 220°C, iron dissolves and remains in the reaction solution, due to low speed of the high-temperature thermal hydrolysis reaction, resulting in increase in the solution purification load for iron removal, which makes it very difficult to separate the iron from nickel. On the other hand, the temperature over 280°C is not suitable, because not only selection of a material of a reactor to be used for High Pressure Acid Leach is difficult but also steam cost for raising temperature increases, although the high-temperature thermal hydrolysis reaction itself is accelerated.

The addition amount of sulfuric acid in the above leaching step is not especially limited, and a little excess amount than
amount of stoichiometry required to leach iron in an ore and convert it to hematite is used, for example, the amount of 300 to 400 kg per ton of the ore. That is, the addition amount of sulfuric acid over 400 kg per one ton of the ore, is not preferable, due to increased cost of the sulfuric acid and cost of a neutralizing agent to be used in the later step.

Use amount of the above sulfuric acid is not especially limited, however, it is preferably 25 to 50 g/L, more preferably 35 to 45 g/L, as concentration of free sulfuric acid at the time of leaching completion. In this way, true density of the leaching residue can be increased, the leaching residue with true density can be produced stably, and solid-liquid separation performance of slurry can be enhanced, therefore simplification of equipment of the solid-liquid separation step, which is the next step, can be performed. That is, the concentration below 25 g/L provides insufficient sedimentation concentration of a solid part in sedimentation of slurry containing the leaching residue, and makes a floating solid part remained in the supernatant. This is because reaction rate of thermal hydrolysis at high temperature becomes slow and dehydration of iron hydroxide proceeds insufficiently, and hematite with low true density is formed. On the other hand, the concentration over 50 g/L requires enhancement of durability of leaching equipment, and in addition, extremely increases use amount of a neutralizing agent to be required in neutralization of an acid, and is thus disadvantageous in view of cost.

(3) A solid-liquid separation step
The above solid-liquid separation step is a step for obtaining a leach solution containing a nickel and a cobalt, and a leaching residue slurry, by multi-stage washing of the leaching slurry formed in the above leaching step. By this step, nickel, which is adhered onto the leaching residue and disposed, is recovered in the leach solution.

(4) A neutralization step

The above neutralization step is a step for forming a neutralization precipitate slurry containing a ferric iron, and a mother liquor for nickel recovery, by the addition of calcium carbonate into the leach solution obtained in the above-described leaching step, under prevention of oxidation thereof, so that pH becomes equal to or lower than 4, preferably 3.2 to 3.8. By this step, the excess acid used in the above leaching step is neutralized, as well as removal of a ferric iron ion remained in a solution is carried out. That is, pH over 4 increases generation of nickel hydroxide.

The resulting neutralization precipitate slurry is sent to the final neutralization step (2), which corresponds to the step of newly added (C), for further treatment.

(5) A zinc removal step

The above zinc removal step is a step for forming a zinc sulfide precipitate slurry and a mother liquor for nickel and cobalt recovery, by blowing a hydrogen sulfide gas into the above mother liquor in advance to the separation step of nickel and cobalt as sulfides. This is for selective removal of zinc, by prevention of sulfurization reaction rate by creating the weak
condition in the sulfurization reaction, and prevention of co-precipitation of coexisting nickel having higher concentration as compared with zinc.

The resulting zinc sulfide precipitate slurry is sent to the final neutralization step (2), similarly as the neutralization precipitate slurry obtained in the above, for further treatment.

(6) A sulfurization step

The above-described sulfurization step is a step for forming a mixed sulfide containing a nickel and a cobalt, and a barren liquor, by blowing a hydrogen sulfide into the mother liquor for nickel and cobalt recovery obtained in the above zinc removal step.

Here, the resulting barren liquor has a pH of about 1 to 3, and contains impurities such as iron, magnesium, manganese contained in a non-sulfurized state, as well as trace amount of nickel and cobalt, as recovery loss, therefore, it is used as washing water of the leaching residue in the solid-liquid separation step, and as washing water of the neutralization residue produced in the neutralization step.

(7) A final neutralization step (1) and the step of (B)

The above final neutralization step (1) is a step for obtaining a final neutralization residue (1) containing the leaching residue, by the addition of an excess barren liquor into the above leaching residue slurry, and by the addition of lime stone slurry and slaked lime slurry thereto, by adjustment of pH to about 8 to 9 and by precipitation of the metal ions
in liquid.

The above leaching residue contains hematite as a main component, and contains gangue component such as quartz, chromite, a magnesium silicate ore, which is not leached in the above leaching step.

Here, explanation will be given on a distribution state of each of the components in the ore particles composing the above-described leaching residue slurry.

Firstly, Table 4 shows one example of ore particle size distribution and content of each component in each particle size classification, of the leaching residue obtained in leaching of the ore slurry (refer to Table 1) obtained in advance by crushing to a particle size of equal to or smaller than about 2 mm.

<table>
<thead>
<tr>
<th>Particle size (μm)</th>
<th>Distribution rate (% by mass)</th>
<th>Chemical composition (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2000 to +1400</td>
<td>0</td>
<td>Fe</td>
</tr>
<tr>
<td>-1400 to +850</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>-850 to +355</td>
<td>0.1</td>
<td>26</td>
</tr>
<tr>
<td>-355 to +75</td>
<td>0.7</td>
<td>45</td>
</tr>
<tr>
<td>-75</td>
<td>99.1</td>
<td>44.6</td>
</tr>
<tr>
<td>Average</td>
<td>100</td>
<td>44.6</td>
</tr>
</tbody>
</table>

From Table 4, it is understood that iron is concentrated in the fine particle part of equal to or smaller than 75 μm, and silicon is separated in this part. It should be noted that, analysis of the leaching residue was carried out on a sample
from which adhered sulfuric acid was removed by washing of the leaching residue slurry with water.

Next, by using a leaching residue (iron content: 47.6% by mass, chromium content: 2.6% by mass, silicon content: 7.1% by mass) different from the above-described, content or distribution rate of iron, chromium and silicon by each particle size was determined. Figures 3 and 4 show the relation between particle size and content or distribution rate of iron, chromium and silicon. From these Figures 3 and 4, it is understood that the finer particle size has the higher iron content, and the higher distribution rate to the fine particle as compared with chromium and silicon.

From the above results, by utilization of the fact that particles containing an iron in high content are finer particles than particles containing a chromium, a silicon and the like in high content, the coarse particle part containing a chromium, a silicon and the like in high content is separated by a selection means such as a classification method, and discharged outside a system, and hematite can be recovered as a resource.

The step of the above (B) is a step for separation and recovery, by a physical separation method, of hematite particles in leaching residue produced from the above solid-liquid separation step. It should be noted that, the step of (B) may be carried out by being included in the above final neutralization step (1), or in the subsequent step thereto. It should be noted that, introduction of the step of (B) before
neutralization is desirable to avoid entrainment of gypsum to be described later, however, there is a problem of requiring a large quantity of water for washing to remove adhered sulfuric acid.

A method for step of the above (B) is not especially limited, and there may be applied the methods using physical separation means by various wet processes such as sieving classification, sedimentation classification, centrifugal classification, magnetic separation method, which enable to separate hematite from the ore slurry.

For example, there is adopted a method for subjecting a leaching residue slurry or the final neutralization residue slurry containing it to physical separation method by sieving classification or centrifugal classification, for recovering thus classified fine particle part as a concentrate of hematite.

That is, in the above-described classification, hematite is distributed in the classified fine particle part, on the other hand, gangue components is distributed in the classified coarse particle part.

Classification particle size in the above classification is not especially limited, however, it is preferably selected from a range of 20 to 100 \( \mu \)m. Here the classification particle size should be determined in consideration of iron content of hematite precipitate and yield or the like, however, the classification particle size below 20 \( \mu \)m decreases amount of the leaching residue of this particle size classification, and thus deteriorates efficiency in view of iron recovery. On the
other hand, the classification particle size over 100 \( \mu m \) provides insufficient concentration of hematite in the fine particle part, that is, increase in iron content.

Here, explanation will be given on an analysis of distribution state of each of the components in the ore particles composing the above-described final neutralization residue.

Table 5 shows one example of ore particle size distribution and content of each component in each particle size classification, of the final neutralization residue obtained in leaching and subjecting to neutralization treatment of the ore slurry (refer to Table 4) obtained by crushing to a particle size of equal to or smaller than about 2 mm.

<table>
<thead>
<tr>
<th>Particle size (( \mu m ))</th>
<th>Distribution rate (% by mass)</th>
<th>Chemical composition (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fe</td>
</tr>
<tr>
<td>-2000 to +1400</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>-1400 to +850</td>
<td>0.8</td>
<td>12</td>
</tr>
<tr>
<td>-850 to +355</td>
<td>1.5</td>
<td>11</td>
</tr>
<tr>
<td>-355 to +75</td>
<td>14.6</td>
<td>9</td>
</tr>
<tr>
<td>-75</td>
<td>82.9</td>
<td>41</td>
</tr>
<tr>
<td>Average</td>
<td>100</td>
<td>35.7</td>
</tr>
</tbody>
</table>

From Table 5, it is understood that in the fine particle part of equal to or smaller than 75 \( \mu m \), iron is concentrated and content of silicon, calcium or the like is decreased. That is, it is understood that, in this part, a gangue component and hematite are separated. It should be noted that, presence of calcium is brought about by generation and entrainment of gypsum.
in neutralization in the final neutralization step (1), and it is understood that this gypsum is distributed in the fine particle size part.

From the above results, by utilization of the fact that hematite particles are finer than other leaching residue components and gypsum generated by a neutralization reaction, in separation and recovery of hematite from the final neutralization residue slurry containing the leaching residue slurry as well, physical separation means by various wet processes, such as sieving classification, sedimentation classification, centrifugal classification may be applied, similarly as in the case of the leaching residue slurry, which enables to separate to the fine particle size part containing a hematite, and the coarse particle size part containing other leaching residue components and the gypsum. Here, the fine particle part is discharged outside a system and purified in the separate step for recovering a hematite as an iron resource. It should be noted that, the coarse particle part is stored in a tailing dam as a final neutralization residue (1).

In addition, as a method of step of the above (B), a magnetic selection method by utilization of magnetic separation may be applied, and in particular, as a method for enhancing the separation of the above-described gypsum, combined use with the above classification method may be carried out. That is, the magnetic selection method utilizes the fact that hematite is a weak magnetic substance, and on the other hand, gypsum is a non-magnetic substance, and this property difference is
utilized in separation.

It should be noted that, in order to prevent basically entrainment of calcium to a hematite precipitate to be recovered, it is effective to remove adhered sulfuric acid so as to decrease sulfur content to equal to or lower than about 1% by mass, by adoption of a method for washing the leaching residue slurry with water having a low calcium concentration, before treatment in the final neutralization step (1), however, there is a problem that water having a low calcium concentration cannot always be secured in a large quantity, depending on locational condition.

(8) A final neutralization step (2)

The above final neutralization step (2) is a step for obtaining a final neutralization residue (2), by the addition of lime stone slurry and slaked lime slurry to the neutralization precipitate slurry obtained in the above neutralization step or, if necessary, addition thereto of the zinc sulfide precipitate slurry obtained in the above zinc removal step, so as to adjust pH to about 8 to 9, for sedimentation of metal ions in a solution as a neutralization precipitate. It should be noted that, the resulting final neutralization residue (2) is stored in a tailing dam.

It should be noted that, conventionally the neutralization precipitate slurry obtained in the above neutralization step has been sent to the solid-liquid separation step, if necessary, however, it increased consumption amount of a neutralizing agent, as well as increased amount of the leaching residue. As in the
method of the present invention, in separation and recovery of hematite from the leaching residue, in order to increase hematite content in the leaching residue, it is preferable to treat the neutralization precipitate slurry in a separate system.

EXAMPLES

Explanation will be given below in still more detail on the present invention, with reference to Examples of the present invention, however, the present invention should not be limited to these Examples. It should be noted that, analysis of metals used in Examples was carried out by a fluorescent X-ray analysis method or an ICP emission spectrometry.

(Example 1)

As the above-described step (A), a silica mineral, a chromite and a magnesium silicate ore were concentrated and separated from an ore slurry by centrifugal classification.

As a classification apparatus, a Knelson concentrator (manufactured by Knelson Engineering and Manufacturing Division) having a centrifugal force of maximal 100 G was used to carry out classification of the ore slurry shown in the above-described Table 1.

Here, the slurry concentration was set at 15% by mass, and solution temperature was set at normal temperature.

Obtained results are shown in Table 6.
Table 6

<table>
<thead>
<tr>
<th>Amount (% by mass)</th>
<th>Chemical composition (%) by mass</th>
<th>Distribution rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ore supplied</td>
<td>Fine particle part</td>
</tr>
<tr>
<td>Ni</td>
<td>1.36</td>
<td>1.36</td>
</tr>
<tr>
<td>Fe</td>
<td>45.7</td>
<td>47.0</td>
</tr>
<tr>
<td>Mg</td>
<td>2.00</td>
<td>1.71</td>
</tr>
<tr>
<td>Si</td>
<td>6.60</td>
<td>5.9</td>
</tr>
<tr>
<td>Cr</td>
<td>2.71</td>
<td>2.42</td>
</tr>
<tr>
<td>Ca</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>
It is shown from Table 6 that, by the centrifugal classification, content of chromium, silicon and magnesium in the resulting coarse particle part increased up to 5.3% by mass relative to 2.7% by mass in the feeding, 12.5% by mass relative to 6.6% by mass in the feeding, as well as 4.6% by mass relative to 2.0% by mass in the feeding, respectively, and on the other hand, content of iron decreased down to 34.4% by mass relative to 45.7% by mass in the feeding.

From the above, it is understood that the silica mineral, chromite and the magnesium silicate ore were concentrated and separated in the coarse particle part by classification of the ore slurry.

(Example 2)

As step of the above (B), hematite was concentrated and separated from a leaching residue by centrifugal classification.

Using the ore slurry shown in the above-described Table 1, sulfuric acid with a concentration of 45 g/L was added to the slurry with a concentration of 30% by mass, which was charged into an autoclave equipped with a stirrer, to carry out leaching for 60 minutes after a predetermined leaching temperature of 245°C was attained. Then, after completion of the leaching, leaching residue and leach solution were separated by filtration, and the resulting leaching residue (refer to the above-described Table 4) was classified using a similar classification apparatus as one used in Example 1.

It should be noted that, composition of the leach solution
77486-26D1

was Ni: 7.1 g/L, Co: 0.6 g/L, and Fe: 5 g/L.

Obtained results are shown in Table 7.
<table>
<thead>
<tr>
<th>Amount (%) by mass</th>
<th>Chemical composition</th>
<th>Distribution rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ore supplied</td>
<td>Fine particle part</td>
</tr>
<tr>
<td>Ni</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Fe</td>
<td>44.6</td>
<td>52.4</td>
</tr>
<tr>
<td>Mg</td>
<td>1.33</td>
<td>0.97</td>
</tr>
<tr>
<td>Si</td>
<td>7.80</td>
<td>6.1</td>
</tr>
<tr>
<td>Cr</td>
<td>2.52</td>
<td>2.2</td>
</tr>
<tr>
<td>Ca</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>
It is shown from Table 7 that content of iron in the resulting fine particle part increased up to 52.4% by mass relative to 44.6% by mass in the feeding, and on the other hand, contents of chromium, silicon and magnesium decreased down to 2.2% by mass relative to 2.52% by mass in the feeding, down to 6.1% by mass relative to 7.8% by mass in the feeding, down to 0.97% by mass relative to 1.33% by mass in the feeding, respectively.

From the above, it is understood that hematite is concentrated and separated in the fine particle part by classification of the leaching residue.

(Example 3)

As step of the above (B), hematite was concentrated and separated from a final neutralization residue by centrifugal classification.

Slaked lime slurry with a concentration of 25% by mass was added, as a neutralizing agent, into the above leaching residue (refer to the abovc-described Table 4) for neutralization so as to attain a pH of 8.5 at 60°C. Still more, the resulting final neutralization residue (refer to the above Table 5) was classified using a similar classification apparatus as one used in Example 1. Obtained results are shown in Table 8.
<table>
<thead>
<tr>
<th>Chemical composition (by mass)</th>
<th>Amount supplied (by mass)</th>
<th>Distribution rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ore part</td>
<td>Fine particle part</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Fe</td>
<td>35.7</td>
<td>40.2</td>
</tr>
<tr>
<td>Mg</td>
<td>1.42</td>
<td>1.60</td>
</tr>
<tr>
<td>Si</td>
<td>8.10</td>
<td>8.0</td>
</tr>
<tr>
<td>Cr</td>
<td>2.00</td>
<td>2.1</td>
</tr>
<tr>
<td>Ca</td>
<td>5.92</td>
<td>3.5</td>
</tr>
</tbody>
</table>
It is shown from Table 8 that content of iron in the resulting fine particle part increased up to 40.2% by mass relative to 35.7% by mass in the feeding, by centrifugal separation. From the above, it is understood that hematite is concentrated and separated in the fine particle part by classification of the final neutralization residue slurry.

(Example 4)

As step of the above (B), hematite was concentrated and separated from the final neutralization residue by magnetic selective separation.

Using the final neutralization residue slurry (refer to the above Table 5), magnetic selection was carried out by using a high gradient magnetic separator (HGMS). It should be noted that, final neutralization condition was similar to that in Example 3. Obtained results are shown in Table 9.

Table 9

<table>
<thead>
<tr>
<th>Amount (% by mass)</th>
<th>Chemical composition (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ore supplied</td>
</tr>
<tr>
<td>Ni</td>
<td>0.08</td>
</tr>
<tr>
<td>Fe</td>
<td>35.7</td>
</tr>
<tr>
<td>Mg</td>
<td>1.42</td>
</tr>
<tr>
<td>Si</td>
<td>8.1</td>
</tr>
<tr>
<td>Cr</td>
<td>1.8</td>
</tr>
<tr>
<td>Ca</td>
<td>5.9</td>
</tr>
</tbody>
</table>

It is shown from Table 9 that content of iron in the
resulting magnetized substance increased up to 48.5% by mass relative to 35.7% by mass in the feeding, and on the other hand, content of calcium decreased down to 0.6% by mass relative to 5.9% by mass in the feeding. Recovery rate of slurry here was 51%. From this, it is understood that concentration of hematite to the magnetized substance and decrease in gypsum proceed.

(Example 5)

As step of the above (B), hematite was concentrated and separated from the leaching residue by sieving separation.

Using the leaching residue (iron content: 47.6% by mass, chromium content: 2.6% by mass, and silicon content: 7.1% by mass) shown in the above Figures 3 and 4, each wet-type sieving were carried out using sieves with a mesh opening of 20 μm and 75 μm, to determine contents of chromium and silicon of a fine particle part, and distribution rate thereof. Results obtained are shown in Table 10.
Table 10

<table>
<thead>
<tr>
<th>Classification Particle size</th>
<th>Iron</th>
<th></th>
<th>Chromium</th>
<th></th>
<th>Silicon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Content (%)</td>
<td>Distribution rate (%)</td>
<td>Content (%)</td>
<td>Distribution rate (%)</td>
<td>Content (%)</td>
<td>Distribution rate (%)</td>
</tr>
<tr>
<td>20µm</td>
<td>53.2</td>
<td>89.2</td>
<td>1.4</td>
<td>43.4</td>
<td>4.3</td>
<td>48.6</td>
</tr>
<tr>
<td>75µm</td>
<td>50.6</td>
<td>95.8</td>
<td>2.0</td>
<td>70.9</td>
<td>5.4</td>
<td>68.4</td>
</tr>
</tbody>
</table>
From Table 10, it is understood that a hematite concentrate (iron content: 50.6 and 53.2% by mass) having low contents of chromium and silicon in the fine particle part, can be obtained, by wet-type sieving where classification particle size is set at a range of 20 μm and 75 μm.

(Example 6)

As step of the above (B), hematite was concentrated and separated from the leaching residue by centrifugal classification.

By using the leaching residues obtained through the above Example 1 to Example 3, centrifugal classification was carried out. However, there was not carried out the separation of chromium and silica by classification before the leaching in Example 1, in order to confirm separation effect of chromium and silica by classification after the leaching residue of the present invention.

For the centrifugal separation, a hydro-cyclone (an SP-50 model, manufactured by Japan Separation Co., Ltd.) having a rated classification point of 50 μm was used. Here, by supplying an under-flow part of the first stage of the cyclone, where the leaching residue slurry was supplied, into the second stage of the cyclone, crude coarse particles (under-flow) and crude fine particles (over-flow) were obtained. In addition, by supplying over-flow part of the first stage of the cyclone into the third stage of the cyclone, fine crude particles (under-flow) and sufficiently fine particles (over-flow) were obtained. After that, distribution rates and compositions of these products were determined. Results are shown in Table 11.
<table>
<thead>
<tr>
<th></th>
<th>Amount (% by mass)</th>
<th>Chemical composition (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe</td>
<td>Cr</td>
</tr>
<tr>
<td>Ore supplied</td>
<td>100</td>
<td>57.1</td>
</tr>
<tr>
<td>Sufficiently fine</td>
<td>70</td>
<td>61.2</td>
</tr>
<tr>
<td>particle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine coarse particle</td>
<td>9</td>
<td>57.2</td>
</tr>
<tr>
<td>Crude fine particle</td>
<td>6</td>
<td>58.6</td>
</tr>
<tr>
<td>Crude coarse particle</td>
<td>15</td>
<td>39.2</td>
</tr>
</tbody>
</table>
From Table 11, it is understood that sufficiently fine particle with an iron content of 61% by mass, showing a physical distribution rate of 70%, can be obtained.

(Example 7)

As the above (A), chromite was concentrated and separated from the ore slurry by sieving classification.

By using the ore slurry shown in the above Table 2, contents of nickel, iron, chromium, silicon and magnesium, and distribution rate thereof were determined for particle size range A: 100 to 850 μm, particle size range B: 75 to 1000 μm, particle size range C: 37 to 850 μm, particle size range D: 37 to 1000 μm, and particle size range F: equal to or smaller than 100 μm, in the case where a wet-type sieving was carried out using sieves with each mesh opening of 37 μm, 75 μm, 100 μm, 850 μm, and 1000 μm.

From the above Table 3, it is understood that a concentrate of chromite with a chromium content of equal to or more than 10% by mass can be obtained for the particle size range C: 37 to 850 μm, and particle size range D: 37 to 1000 μm. In addition, it is understood that, for the particle size range G: equal to or larger than 1000 μm, silicon content and magnesium content increase to 10.6% by mass and 9% by mass, respectively, and a silica mineral and a magnesium silicate ore are concentrated and separated into a coarse particle part.

In particular, for the particle size range A: 100 to 850 μm and the particle size range B: 75 to 1000 μm, a concentrate of chromium with a chromium content of about 20% by mass can be obtained. Still more, it is understood that nickel content
in the concentrate is 0.5% by mass and thus nickel loss can be prevented to the minimum, and for the particle size range F:

equal to or smaller than 100 µm, chromium content reduces down to 1.7% by mass, and on the other hand, iron and nickel are concentrated.

(Example 8 and Reference Example 1)

According to a process chart of smelting, shown in Figure. 1, a hydrometallurgical process of a nickel laterite ore containing the steps of (A), (B) and (C) was carried out to separate chromite, a silica mineral and a magnesium silicate ore and concentration and separation of hematite.

Firstly, as the step of (A), by using the ore slurry shown in the above Table 2, it was subjected to wet-sieving classification with a sieve having a mesh opening of 75 µm, for separation of chromite, a silica mineral and a magnesium silicate ore as a coarse particle part. Then as the leaching step, by using the resulting fine particle part, sulfuric acid with a concentration of 45 g/L was added to the slurry with a concentration of 30% by mass, which was charged into an autoclave equipped with a stirrer, to carry out leaching for 60 minutes after a leaching temperature of 245°C, and the leaching residue and leach solution were obtained. Subsequently, as the final neutralization step, slaked lime slurry with a concentration of 25% by mass was added as a neutralizing agent, into the resulting leaching residue slurry, for neutralization so as to attain a pH of 8.5 at 60°C, and lastly, as the step of (B), by using the resulting neutralization residue, it was classified to a fine particle part concentrated with hematite and a coarse
particle part concentrated with gypsum, by a hydro-cyclone (a 
NHC-1 model, manufactured by Japan Chemical Engineering & 
Machinery Co., Ltd.) having a centrifugal force of maximal 24000 
G, and contents of iron, calcium, sulfur, chromium, silicon and 
magnesium in the fine particle part were determined (Example 
8). Results are shown in Table 12. It should be noted that, as 
the step of (C), neutralization precipitate slurry obtained from 
the neutralization step of the above-described leach solution, 
was subjected to final neutralization treatment separately from 
the above-described leaching residue.

On the other hand, similarly as in Example 8, except that 
the above leach solution was neutralized, under maintaining at 
60°C, by the addition of 25% by mass slaked lime slurry, as a 
neutralizing agent, so that pH becomes 2.5, to obtain 
neutralization precipitate slurry containing ferric iron 
hydroxide, and by mixing this with the leaching residue, 
contents of iron, calcium, sulfur, chromium, silicon and 
magnesium of the fine particle part were determined (Reference 
Example 1). Results are shown in Table 12.

Table 12

<table>
<thead>
<tr>
<th>Chemical composition (% by mass)</th>
<th>Fe</th>
<th>Ca</th>
<th>S</th>
<th>Cr</th>
<th>Si</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 8</td>
<td>57</td>
<td>1.6</td>
<td>2.4</td>
<td>1.6</td>
<td>1.5</td>
<td>0.10</td>
</tr>
<tr>
<td>Reference Example 1</td>
<td>48</td>
<td>4.2</td>
<td>4.8</td>
<td>1.5</td>
<td>1.2</td>
<td>0.15</td>
</tr>
</tbody>
</table>

From Table 12, it is understood that, in Example 8, iron 
content of the fine particle part enhances to 57%, and at the 
same time, calcium content decreases to 1.6% by mass, and a 
concentrate of hematite with quality usable as a raw material
of iron and steel can be obtained. On the other hand, in Reference Example 1, it is understood that separation of iron and calcium is insufficient.

As is clear from the above, the hydrometallurgical process of a nickel laterite ore of the present invention is suitable as a smelting based on High Pressure Acid Leach to be utilized in the field of a hydrometallurgical process of a nickel laterite ore.
CLAIMS:

1. A hydrometallurgical process for a nickel laterite ore to recover nickel and cobalt from the nickel laterite ore by a High Pressure Acid Leach comprising an ore treatment step for forming an ore slurry by removing foreign material and adjusting ore particle size of a mined raw material ore; a leaching step forms a leaching slurry composed of leaching residue and leach solution, by the addition of sulfuric acid to said ore slurry and by stirring treatment under high temperature and high pressure; a solid-liquid separation step which gives a leach solution comprising nickel and cobalt, and a leaching residue slurry, by multi-stage washing of said leaching slurry; a neutralization step which forms a neutralization precipitate slurry comprising ferric iron, and a mother liquor for nickel recovery, by the addition of calcium carbonate into said leach solution; a zinc removal step which forms a zinc sulfide precipitate slurry, and a mother liquor for nickel and cobalt recovery, by blowing hydrogen sulfide gas into said mother liquor; a sulfurization step which forms a mixed sulfide comprising nickel and cobalt, and a barren liquor, by blowing hydrogen sulfide into said mother liquor for nickel and cobalt recovery; and a final neutralization step which gives a final neutralization residue slurry, by the addition of an excess barren liquor into said leaching residue slurry, and adjusting pH to about 8 to 9, which neutralization step comprises the following step (B):

   (B) separation and recovery, by a physical separation method, of hematite particles from the leaching residue slurry produced from the solid-liquid separation step.
2. The hydrometallurgical process according to claim 1, wherein in the ore treatment step, ore particle size adjustment is subjected to a sieve treatment at a particle size of equal to or smaller than 2 mm.

3. The hydrometallurgical process according to any one of claims 1 and 2, wherein step (B), the leaching residue slurry or the final neutralization residue slurry comprising the leaching residue slurry is subject to the physical separation method by sieve classification or centrifugal classification, wherein the fine particle part classified is recovered as a concentrate of hematite.

4. The hydrometallurgical process according to claim 3, wherein the classified particle size is selected from a range of 20 to 100 μm.

5. The hydrometallurgical process according to any one of claims 1 and 2, wherein in step (B), the leaching residue slurry or the final neutralization residue slurry comprising the leaching residue slurry is subjected to the physical separation method by magnetic separation, wherein a magnetized substance is recovered as a concentrate of hematite.
Figure 1

8. nickel laterite ore

1. ore treatment step

2.1. step (A)

9. ore slurry 2.2. chromite or the like

2. leaching step

10. leaching slurry

3. solid-liquid separation step

leach

11. solution 12. leaching residue slurry

4. neutralization step

13. neutralization precipitate slurry 14. liquor (1)

5. zinc removal step

15. zinc sulfide 16. mother precipitate liquor (2)

7. final neutralization step (1)

23. step (B)

17. mixed sulfide liquor

18. barren liquor

25. final neutralization step (2) [step (C)]

19. final neutralization residue (1)

20. tailing dam

24. precipitate hematite
Figure 2

8. nickel laterite ore
    ↓
1. ore treatment step
    ↓
9. ore slurry
    ↓
2. leaching step
    ↓
10. leaching slurry
    ↓
3. solid-liquid separation step
    ↓
11. leach solution 12. leaching residue slurry
    ↓
4. neutralization step
    ↓
13. neutralization precipitate slurry
    ↓
14. liquor (1)
    ↓
5. zinc removal step
    ↓
15. zinc sulfide precipitate
    ↓
16. mother liquor (2)
    ↓
6. sulfuration step
    ↓
17. mixed sulfide
    ↓
18. barren liquor
    ↓
19. final neutralization residue
    ↓
20. tailing dam

PRIOR ART
Figure 3

Figure 4