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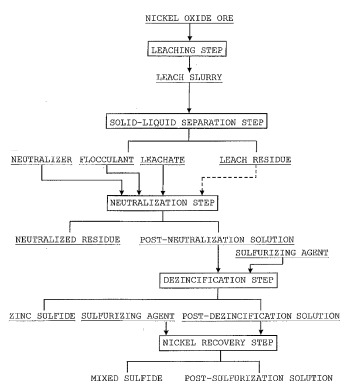
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(54) **WET METALLURGY METHOD FOR NICKEL OXIDE ORE**

(57) Disclosed herein is a hydrometallurgical method for nickel oxide ore based on high pressure acid leaching which is capable of increasing the recovery rate of nickel in a dezincification step of removing zinc contained in the ore.

The hydrometallurgical method includes: a leaching step S1 in which nickel oxide ore is subjected to acid leaching under high pressure to obtain a leachate; a neutralization step S3 in which a neutralizer is added to the leachate to generate a neutralized precipitate, and the neutralized precipitate is removed to obtain a post-neutralization solution; a dezincification step S4 in which hydrogen sulfide gas is blown into the post-neutralization solution to generate a zinc precipitate, and the zinc precipitate is removed to obtain a post-dezincification solution; and a nickel recovery step S5 in which a sulfurizing agent is added to the post-dezincification solution to recover nickel as a sulfide, wherein the hydrogen sulfide gas is blown into two or more reaction tanks connected in series to allow the post-neutralization solution to flow therethrough in order in such a manner that an amount of the hydrogen sulfide gas blown into the second and following reaction tanks from top is adjusted to 50% or more but 90% or less of a total amount of the hydrogen sulfide gas blown into all the reaction tanks.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a hydrometallurgical method in which nickel oxide ore is subjected to high-pressure acid leaching, and more particularly relates to a hydrometallurgical method capable of increasing a nickel recovery rate.

Background Art

[0002] As one of hydrometallurgical method methods of nickel oxide ore, a high pressure acid leach (HPAL) process using sulfuric acid is known. This process is different from a conventional pyrometallurgical process generally used as a smelting method for nickel oxide ore in that nickel oxide ore is processed under wet conditions throughout the process without performing an oxide ore reduction step and drying step at high temperature, and is therefore advantageous in terms of energy and cost. Further, the HPAL process allows to obtain a nickel- and cobalt-containing sulfide (hereinafter also referred to as a nickel/cobalt mixed sulfide) which is concentrated to a nickel grade of about 50 to 60% by mass, and therefore high purity nickel can easily be obtained by refining.

[0003] When nickel oxide ore as a raw material is subjected to high pressure acid leaching to recover nickel as a product, the nickel oxide ore is generally often processed through the following steps (a) to (d):

(a) a leaching and solid-liquid separation step in which water is added to crushed nickel oxide ore to obtain a slurry, sulfuric acid is then added to the slurry, the mixture is placed in a reaction container such as an autoclave and maintained at a temperature of about 240 to 280°C under high pressure to leach valuables such as nickel and cobalt contained in the nickel oxide ore, and the slurry is taken out of the reaction container after leaching and subjected to solid-liquid separation in a sedimentation tank to separate a leachate containing nickel and cobalt from a leach residue;

(b) a neutralization step in which the leachate is adjusted to a predetermined pH by adding a neutralizer to precipitate an impurity such as iron to obtain a neutralized slurry, a coagulant is added to the neutralized slurry containing a neutralized precipitate of the impurity to separate the neutralized precipitate by solid-liquid separation so as to obtain a post-neutralization solution containing nickel and cobalt;

(c) a dezincification step in which a sulfurizing agent is added to the post-neutralization solution while the amount of the sulfurizing agent added is controlled to be in an appropriate range to remove only zinc and copper as sulfides without sulfurizing nickel and cobalt contained as valuables in the post-neutralization solution, the thus obtained sulfide precipitate (also referred to as zinc precipitate) is separated by solid-liquid separation to obtain a post-dezincification solution; and

(d) a nickel recovery step in which a sulfurizing agent is added to the post-dezincification solution to generate a nickel/cobalt mixed sulfide, and the mixed sulfide is separated and recovered.

[0004] For example, Patent Literature 1 discloses a hydrometallurgical method based on the above-described high pressure acid leaching, which includes a leaching step in which nickel oxide ore is subjected to leaching using sulfuric acid and then to solid-liquid separation to obtain a leachate; a neutralization step in which a neutralizer is added to the leachate to generate a neutralized precipitate containing an impurity, and the neutralized precipitate is removed to obtain a post-neutralization solution; a dezincification step in which hydrogen sulfide gas is added to the post-neutralization solution to generate zinc sulfide, and the zinc sulfide is removed to obtain a mother liquor for nickel recovery; and a nickel recovery step in which hydrogen sulfide gas is added to the mother liquor to recover nickel and cobalt as a mixed sulfide.

[0005] In the method disclosed in Patent Literature 1, a leach residue is appropriately added to the leachate and the pH of the post-neutralization solution is adjusted to 3.0 to 3.5 in the neutralization step, and further a sulfurization reaction is performed in the dezincification step in a state where suspended solids including the neutralized precipitate and the leach residue remain in the post-neutralization solution so that the turbidity of the post-neutralization solution is 100 to 400 NTU (Nephelometric Turbidity Unit). The thus obtained slurry containing a sulfide precipitate is subjected to solid-liquid separation in a filtration step in the dezincification step to obtain the sulfide precipitate and a final solution containing nickel and cobalt.

Citation List

Patent Literature

5 **[0006]** Patent Literature 1: JP 2010-37626 A

Summary of Invention

Technical Problem

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[0007] In the above-described HPAL process using nickel oxide ore as a raw material, conditions for generating a sulfide precipitate of zinc in the dezincification step approximate to conditions for generating a sulfide precipitate of nickel, and therefore there is often a case where nickel loss occurs due to coprecipitation of zinc and nickel in the zinc precipitate. The recovery rate of nickel has a great impact on the economic efficiency of the process, and therefore it is

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desirable to reduce nickel loss as much as possible.
[0008] In light of the above circumstances, it is an object of the present invention to provide a hydrometallurgical method for nickel oxide ore based on high pressure acid leaching which is capable of increasing the recovery rate of nickel by reducing the amount of nickel coprecipitated with impurities such as zinc and copper when zinc contained in the nickel oxide ore is removed.

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Solution to Problem

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[0009] In order to achieve the above object, the present inventors have found that the recovery rate of nickel can be increased by providing two or more reaction tanks connected in series for the dezincification reaction, and by adjusting the distribution ratio of hydrogen sulfide gas blown into the reaction tanks when a dezincification reaction (sulfurization reaction) is performed by sulfurization by adding a sulfurizing agent to a post-neutralization solution obtained by neutralizing a leachate obtained by subjecting nickel oxide ore to high pressure acid leaching. This finding has led to the completion of the present invention.

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[0010] More specifically, the present invention is directed to a hydrometallurgical method for nickel oxide ore, including: a leaching step in which nickel oxide ore is subjected to acid leaching under high pressure, and a leach residue is then removed to obtain a leachate; a neutralization step in which a neutralizer is added to the leachate to generate a neutralized precipitate, and the neutralized precipitate is removed to obtain a post-neutralization solution; a dezincification step in which hydrogen sulfide gas is blown into the post-neutralization solution to generate a zinc precipitate, and the zinc precipitate is removed to obtain a post-dezincification solution; and a nickel recovery step in which a sulfurizing agent is added to the post-dezincification solution to recover nickel as a sulfide, wherein in the dezincification step, the hydrogen sulfide gas is blown into two or more reaction tanks connected in series to allow the post-neutralization solution to flow therethrough in order in such a manner that an amount of the hydrogen sulfide gas blown into the second and following reaction tanks from top is adjusted to 50% or more but 90% or less of a total amount of the hydrogen sulfide gas blown into all the reaction tanks.

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Advantageous Effects of Invention

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[0011] According to the present invention, it is possible to reduce the amount of nickel coprecipitated with impurities such as zinc and copper when zinc contained in nickel oxide ore is removed, thereby increasing the recovery rate of nickel.

Brief Description of Drawings

[0012]

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FIG. 1 is a process flow chart showing a hydrometallurgical method for nickel oxide ore according to an embodiment of the present invention.

FIG. 2 is a graph obtained by plotting a relationship between the particle diameter of each of samples of zinc sulfide obtained in Examples and the blowing ratio of hydrogen sulfide gas during generation of the zinc sulfide.

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FIG. 3 is a graph obtained by plotting a relationship between the Ni grade of each of samples of zinc sulfide obtained in Examples and the blowing ratio of hydrogen sulfide gas during generation of the zinc sulfide.

FIG. 4 is a graph obtained by plotting a relationship between the Ni grade and the particle diameter of each of samples of zinc sulfide obtained in Examples.

Description of Embodiments

[0013] Hereinbelow, a hydrometallurgical method for nickel oxide ore according to an embodiment of the present invention will be described. As shown in FIG. 1, the hydrometallurgical method starts from a leaching step S1 in which nickel oxide ore as a raw material is crushed into small pieces by a crushing means such as a crusher, and water is added thereto to obtain a slurry. Then, sulfuric acid is added to the slurry, and the mixture is placed in a pressure vessel such as an autoclave and subjected to sulfuric acid leaching under high temperature and pressure at, for example, 240 to 280°C to leach nickel and cobalt as valuables.

[0014] Then, in a solid-liquid separation step S2, a slurry obtained by the above-described sulfuric acid leaching is subjected to multistep washing, and then a leach residue is removed from the slurry by solid-liquid separation to obtain a leachate containing nickel, cobalt, and impurity elements. Then, in a neutralization step S3, an alkali such as calcium hydroxide or calcium carbonate is added as a neutralizer to the leachate to adjust the pH of the leachate to precipitate the impurity elements as a neutralized precipitate. Then, a flocculant (coagulant) is added to a slurry containing the neutralized precipitate, and the slurry is subjected to solid-liquid separation to remove the neutralized precipitate to obtain a post-neutralization solution containing nickel and cobalt. It is to be noted that if necessary, the neutralized precipitate obtained in the neutralization step S3 may be returned to the solid-liquid separation step S2. As shown by a dotted line in FIG. 1, at least part of the leach residue obtained in the solid-liquid separation step S2 may be added to the leachate in the neutralization step S3.

[0015] Then, in a dezincification step S4, hydrogen sulfide gas is blown as a sulfurizing agent into the post-neutralization solution to generate a zinc-containing sulfide precipitate (zinc sulfide), and a slurry containing the sulfide precipitate is subjected to solid-liquid separation to remove the zinc sulfide to obtain a post-dezincification solution. Finally, in a nickel recovery step S5, a sulfurizing agent such as hydrogen sulfide gas is added to the post-dezincification solution to generate a nickel/cobalt mixed sulfide containing nickel and cobalt, and a slurry containing the nickel/cobalt mixed sulfide is subjected to solid-liquid separation to recover the nickel/cobalt mixed sulfide and to obtain a post-sulfurization solution (barren solution). As shown in FIG. 1, if necessary, the barren solution may be returned to the solid-liquid separation step S2.

[0016] In the embodiment of the hydrometallurgical method according to the present invention, zinc is selectively precipitated and settled as a sulfide in the dezincification step S4 so as to be separated from nickel and cobalt. At this time, two or more reaction tanks for blowing hydrogen sulfide gas into the post-neutralization solution are provided to perform a sulfurization reaction, and are connected in series so that the post-neutralization solution obtained in the neutralization step flows therethrough in order. Further, the ratio of the amount of hydrogen sulfide gas blown into the second and following reaction tanks from the top out of the reaction tanks connected in series to the amount of hydrogen sulfide gas blown into all the reaction tanks (hereinafter also referred to as "blowing ratio") is adjusted to be in an appropriate range. This makes it possible to reduce the amount of nickel coprecipitated with impurities such as zinc and copper, thereby increasing the recovery rate of nickel.

[0017] More specifically, in the dezincification step S4, when n-number of reaction tanks for performing a dezincification reaction are provided in the order of a No. 1 reaction tank, a No. 2 reaction tank, a No. 3 reaction tank, ... and a No. n reaction tank from the top so that the post-neutralization solution flows therethrough in this order, the ratio of the amount of hydrogen sulfide gas blown into (n-1)-number of reaction tanks including the No. 2 and following reaction tanks to the amount of hydrogen sulfide gas blown into all the reaction tanks from the No. 1 reaction tank to the No. n reaction tank (i.e., blowing ratio) is adjusted to 50% to 90%. This makes it possible to reduce the amount of nickel coprecipitated with impurities such as zinc and copper.

[0018] Further, when the blowing ratio is set to such a high value, particles of the sulfide precipitate can grow to have a large particle size. As a result, solid-liquid separability in the dezincification step can also be improved. In the dezincification step, fine particles of the sulfide precipitate are likely to be formed. Therefore, when a slurry containing such fine particles is subjected to solid-liquid separation using a filtration device such as a filter press, a filter cloth is quickly clogged so that the volume of a liquid that can pass through the filter cloth reduces. In order to recover the filter cloth, the filter cloth needs to be frequently backwashed or replaced, which may reduce production efficiency. However, when the blowing ratio is set to such a high value as described above, particles of the sulfide precipitate have a large diameter so that filterability improves.

[0019] As described above, in order to improve not only the recovery rate of nickel but also solid-liquid separability, the blowing ratio is preferably adjusted to 60% to 90%, more preferably 60% to 85%. This makes it possible to increase the particle diameter of particles of zinc sulfide (also referred to as "zinc sulfide precipitate") to be finally generated which allows to prevent the clogging of a filter cloth of a subsequent filtration device, such as a filter press. As a result, the ability of the filtration device to allow a liquid to pass through it improves, which makes it possible to improve productivity. The reason why such an increase in blowing ratio allows particles of the zinc sulfide precipitate to grow to have a large particle diameter is because when the blowing ratio increases, the number of fine particles of sulfides of impurities including zinc which are generated in an early stage of a sulfurization reaction in the No. 1 reaction tank decreases, and

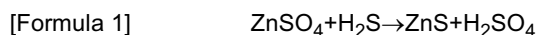
particles of the sulfides grow using these small number of fine particles as nuclei (also referred to as "seeds") in the No. 2 and following reaction tanks.

[0020] When the blowing ratio is less than 60%, the ratio of hydrogen sulfide gas blown into the No. 1 reaction tank is relatively high. In this case, fine particles of zinc sulfide as nuclei are excessively generated in the No. 1 reaction tank, and particles of sulfides grow using these large number of fine particles as nuclei in the No. 2 and following reaction tanks, which makes it difficult to obtain particles of zinc sulfide having a large particle diameter. On the other hand, when the blowing ratio exceeds 90%, generation of fine particles of zinc sulfide as nuclei is suppressed in the No. 1 reaction tank, which leads to a shortage of seeds. In this case, there is a fear that particle grow is insufficient in the No. 2 and following reaction tanks. That is, when more than 10% but less than 40% of hydrogen sulfide gas supplied to all the reaction tanks is blown into the No. 1 reaction tank, seeds can be stably generated. More specifically, the blowing ratio may be appropriately adjusted so that the particles grow to the extent that a filter cloth is not easily clogged in subsequent filtration treatment.

[0021] It is to be noted that when three or more reaction tanks are provided in series, the last reaction tank may serve as a buffer tank into which a large amount of hydrogen sulfide gas is not blown. When the last reaction tank serves as a buffer tank, a reaction time can be secured by the buffer tank even when the short pass of a processed liquid occurs in the reaction tanks located upstream from the last reaction tank, which prevents a reduction in total reaction efficiency. However, the number of reaction tanks for dezincification reaction is preferably 3 or less. This is because when there are a large number of reaction tanks in which substantially no sulfurization reaction occurs, problems occur such as waste of equipment costs and energy costs and redissolution of the zinc sulfide precipitate due to the oxidation of the slurry staying in the excess reaction tanks by air contained in the slurry. Further, zinc sulfide particles separately prepared or zinc sulfide particles recovered by solid-liquid separation may be supplied to the No. 1 reaction tank as seeds, which makes it possible to generate coarser zinc sulfide particles.

[0022] In the dezincification step S4, a dezincification reaction is preferably performed at a pH of 2.5 or higher but 3.5 or lower. If the pH is lower than 2.5, zinc is insufficiently separated due to redissolution of zinc sulfide that has once been generated. On the other hand, if the pH exceeds 3.5, elements, such as iron and nickel, that should not be removed may also be precipitated, which increases a precipitate load on a filter cloth or a filtration device used in subsequent filtration treatment. Particularly, in the case of iron, a large amount of fine precipitate is generated, which promotes the clogging of a filter cloth. Therefore, in order to achieve a sufficient flow rate of the filter cloth, the filter cloth needs to be frequently backwashed, which may reduce production efficiency.

[0023] It is to be noted that in the dezincification reaction, an acid is generated after the reaction as shown in the following formula 1. Therefore, the dezincification reaction is preferably performed while the pH is maintained at 2.7 or higher but 3.0 or lower so that the pH falls within the above range even when an acid is generated.



Examples

[0024] Nickel oxide ore was subjected to hydrometallurgical leaching at high temperature and pressure in accordance with a process flow chart shown in FIG. 1 to recover nickel in the form of a sulfide. More specifically, nickel oxide ore including laterite ore, saprolite ore, and limonite ore and sulfuric acid were placed in an autoclave as a pressure vessel and heated to a temperature of 240 to 260°C by a steam heater to perform leaching under high pressure, and then the obtained leach slurry was subjected to solid-liquid separation to remove a leach residue to obtain a leachate. Calcium hydroxide was added as a neutralizer to the leachate to adjust the pH of the leachate to 3.0 to 3.5 to generate a neutralized precipitate. Then, an anionic flocculant was added to remove the neutralized precipitate by solid-liquid separation to obtain a post-neutralization solution.

[0025] Then, three reaction tanks (No. 1 reaction tank, No. 2 reaction tank, No. 3 reaction tank) were prepared which were connected in series and each of which had an almost cylindrical shape having a diameter of 7.7 m and a height of 12 m (capacity: 460 m³). The post-neutralization solution was continuously supplied to the first No. 1 reaction tank at a flow rate of 1200 to 1450 m³/hr so as to flow through the No. 1 reaction tank, the No. 2 reaction tank, and the No. 3 reaction tank in this order. Further, hydrogen sulfide gas was blown into each of these three reaction tanks to sulfurize zinc contained in the post-neutralization solution to generate zinc sulfide. At this time, the ratio of the amount of hydrogen sulfide gas blown into the No. 2 reaction tank and the No. 3 reaction tank to the amount of hydrogen sulfide gas blown into all the three reaction tanks, that is, the blowing ratio was changed little by little from 5.1% to 86.3%.

[0026] Then, a post-sulfurization solution taken out of the last No. 3 reaction tank was supplied to a Buchner funnel, in which a filter cloth was placed on a perforated plate having a plurality of pores and a diameter of 60 cm, and subjected to solid-liquid separation by vacuum suction on the filtrate side. In this way, zinc sulfide (zinc sulfide precipitate) samples 1 to 46 generated at different blowing ratios were obtained. It is to be noted that blowing of hydrogen sulfide gas into

the No. 2 reaction tank and the No. 3 reaction tank was performed in such a manner that most of the hydrogen sulfide gas was blown into the No. 2 reaction tank, that is, the No. 3 reaction tank was used to react zinc sulfide particles grown in the No. 2 reaction tank with remaining dissolved hydrogen sulfide gas to finally grow the zinc sulfide particles. More specifically, the amount of hydrogen sulfide gas blown into the No. 3 reaction tank was appropriately increased or decreased without changing the blowing ratio on the basis of the particle diameter of sampled grown zinc sulfide particles.

[0027] The following Table 1 shows the blowing ratio during generation of each of the zinc sulfide samples 1 to 46 and the particle diameter of each of the zinc sulfide samples 1 to 46 generated at the shown blowing ratio. FIG. 2 shows a graph obtained by plotting a relationship between the blowing ratio and the particle diameter of zinc sulfide. The particle diameter of zinc sulfide was measured by observing the sample collected during steady operation with a microscope and by using a Microtrac. It is to be noted that the pH and temperature of the slurry in the reaction tanks during generation of the zinc sulfide samples 1 to 46 were maintained at 2.7 to 2.9 and 60 to 67°C, respectively. The composition of the post-neutralization solution was as follows: nickel concentration 3.5 to 4.0 g/L, iron concentration 0.7 to 1.4 g/L, and zinc concentration 60 to 140 mg/L. The zinc concentration of the post-dezincification solution was reduced to about 5 to 12 mg/L.

[Table 1]

Samples	Blowing ratio (%)	Particle diameter of Zn sulfide (μm)
1	5.1	8.1
2	7.6	8.4
3	11.0	9.1
4	11.6	6.9
5	12.9	9.1
6	13.2	7.2
7	13.9	7.9
8	23.7	8.1
9	23.8	9.9
10	23.8	7.7
11	24.1	7.7
12	24.1	9.3
13	28.5	6.6
14	28.6	6.4
15	28.6	8.3
16	30.8	7.7
17	30.8	6.9
18	48.1	7.7
19	48.3	7.0
20	48.8	6.9
21	49.0	8.2
22	51.5	7.9
23	53.5	9.8
24	60.1	11.4
25	63.8	18.1
26	66.4	14.1
27	66.5	10.7
28	66.7	17.8

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(continued)

Samples	Blowing ratio (%)	Particle diameter of Zn sulfide (μm)
29	67.3	10.6
30	67.9	12.5
31	68.4	15.6
32	68.6	11.5
33	69.0	13.6
34	80.1	14.3
35	81.0	19.0
36	81.6	11.0
37	82.0	10.1
38	82.2	16.7
39	83.4	22.6
40	84.1	16.8
41	84.5	28.1
42	84.6	15.0
43	84.8	30.1
44	84.9	18.7
45	86.2	22.0
46	86.3	16.7

[0028] As can be seen from the results shown in Table 1 and FIG. 2, particles of the zinc sulfide samples 24 to 46 obtained by adjusting the ratio of hydrogen sulfide gas blown into the No. 2 and following reaction tanks to 60% or higher but 90% or lower were coarse and had a particle diameter of about 10 μm or more. These zinc sulfide samples 24 to 46 were prepared by continuously performing smelting over several days (at least 24 hours) per sample at different blowing ratios, but a filtration device to which the slurry taken out of the No. 3 reaction tank was supplied was not clogged. On the other hand, particles of all the zinc sulfide samples 1 to 23 prepared at a blowing ratio of less than 60% were fine and had a particle diameter of less than 10 μm . Each of these zinc sulfide samples 1 to 23 were prepared by continuously performing smelting at different blowing ratios, and as a result, a filtration device was clogged before the elapse of 24 hours.

[0029] Then, 37 zinc sulfide samples were randomly selected from the zinc sulfide samples 1 to 46, and their nickel grades were measured by ICP. The nickel grade of the zinc sulfide and the blowing ratio are shown in the following Table 2. FIG. 3 is a graph obtained by plotting a relationship between the nickel grade and the blowing ratio. Further, FIG. 4 is a graph obtained by plotting a relationship between the particle diameter and the nickel grade of the zinc sulfide.

[Table 2]

Samples	Blowing ratio (%)	Ni grade of Zn sulfide (%)
1	5.1	1.7
2	7.6	1.2
5	12.9	1.7
6	13.2	1.7
7	13.9	1.0
8	23.7	1.2
9	23.8	1.2

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(continued)

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Samples	Blowing ratio (%)	Ni grade of Zn sulfide (%)
10	23.8	1.1
11	24.1	1.3
16	30.8	1.7
17	30.8	1.2
18	48.1	1.0
19	48.3	1.3
20	48.8	1.3
21	49.0	1.4
22	51.5	0.6
23	53.5	0.7
24	60.1	0.7
25	63.8	0.5
26	66.4	0.6
27	66.5	0.8
29	67.3	0.6
30	67.9	0.5
31	68.4	0.6
32	68.6	0.4
33	69.0	0.5
34	80.1	0.4
35	81.0	0.8
36	81.6	0.4
37	82.0	0.7
39	83.4	0.4
41	84.5	0.6
42	84.6	0.4
43	84.8	0.6
44	84.9	0.5
45	86.2	0.7
46	86.3	0.8

[0030] As can be seen from Table 2 and FIG. 3, the nickel grade of the zinc sulfide can be reduced to 1% or less by setting the blowing ratio to 50% or more. Further, as can be seen from FIG. 4, the nickel grade of the zinc sulfide can be reduced to 1% or less by allowing particles of the zinc sulfide to have a particle diameter of about 10 μm or more, that is, by setting the blowing ratio of hydrogen sulfide gas to about 60% or more as can be seen from Table 1 and FIG. 2. As described above, when the particle diameter of the zinc sulfide is 10 μm or more, the effect of improving filterability can be obtained in addition to the effect of increasing the recovery rate of nickel.

Claims

- 5 1. A hydrometallurgical method for nickel oxide ore, comprising: a leaching step in which nickel oxide ore is subjected to acid leaching under high pressure, and a leach residue is then removed to obtain a leachate; a neutralization step in which a neutralizer is added to the leachate to generate a neutralized precipitate, and the neutralized precipitate is removed to obtain a post-neutralization solution; a dezincification step in which hydrogen sulfide gas is blown into the post-neutralization solution to generate a zinc precipitate, and the zinc precipitate is removed to obtain a post-dezincification solution; and a nickel recovery step in which a sulfurizing agent is added to the post-dezincification solution to recover nickel as a sulfide, wherein in the dezincification step, the hydrogen sulfide gas is blown into two or more reaction tanks connected in series to allow the post-neutralization solution to flow therethrough in order in such a manner that an amount of the hydrogen sulfide gas blown into the second and following reaction tanks from top is adjusted to 50% or more but 90% or less of a total amount of the hydrogen sulfide gas blown into all the reaction tanks.
- 10
- 15 2. The hydrometallurgical method for nickel oxide ore according to claim 1, wherein in the dezincification step, the sulfurizing reaction is performed in a pH range of 2.5 or higher but 3.5 or lower.
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- 25
- 30
- 35
- 40
- 45
- 50
- 55

FIG. 1

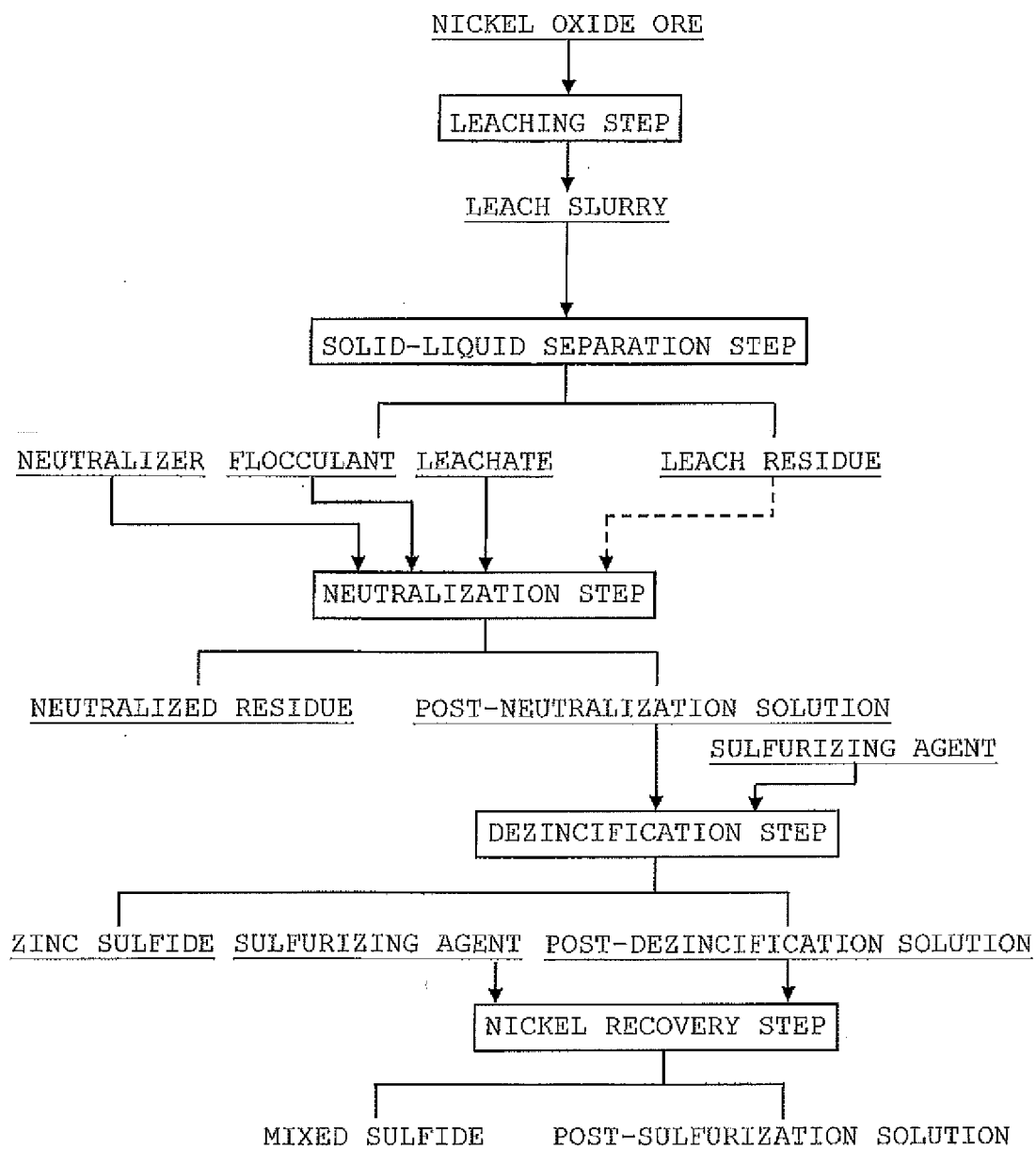


FIG. 2

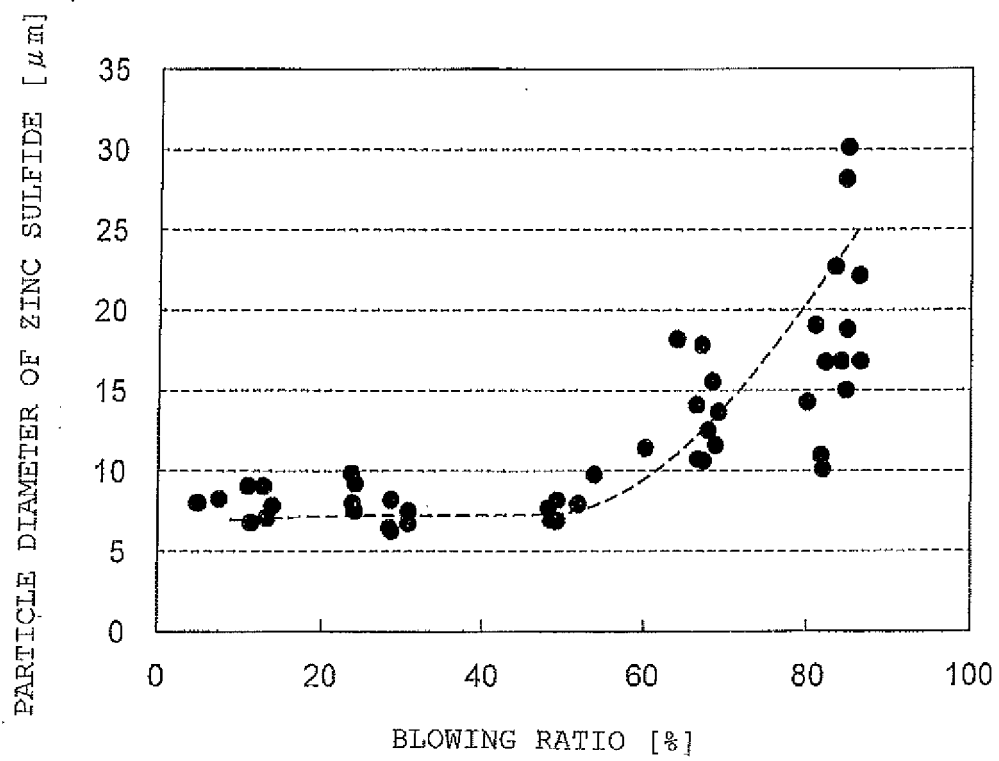


FIG. 3

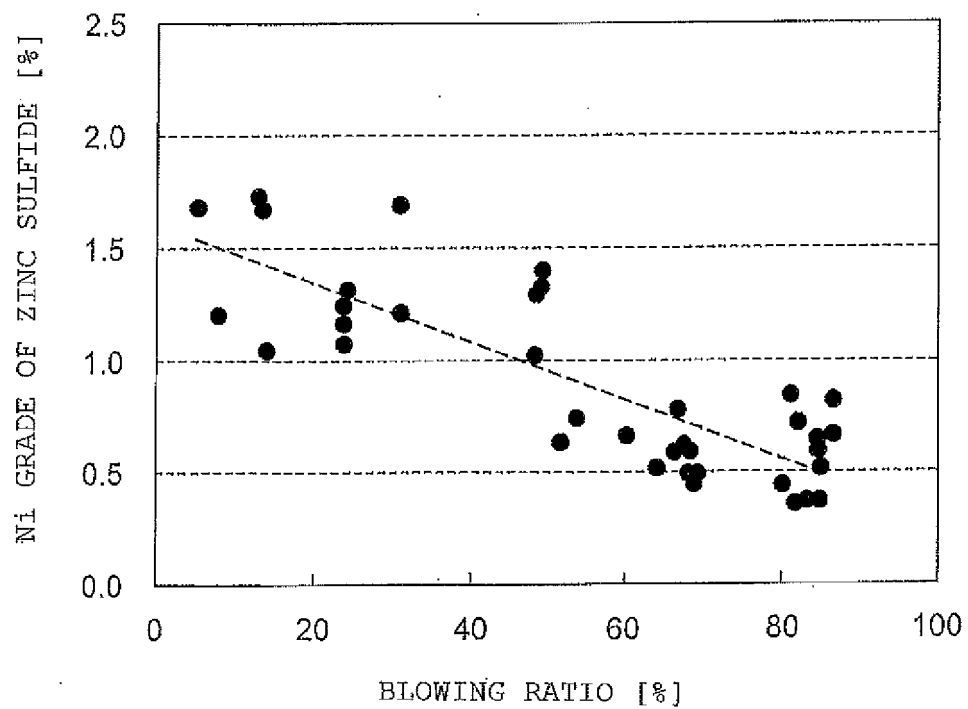
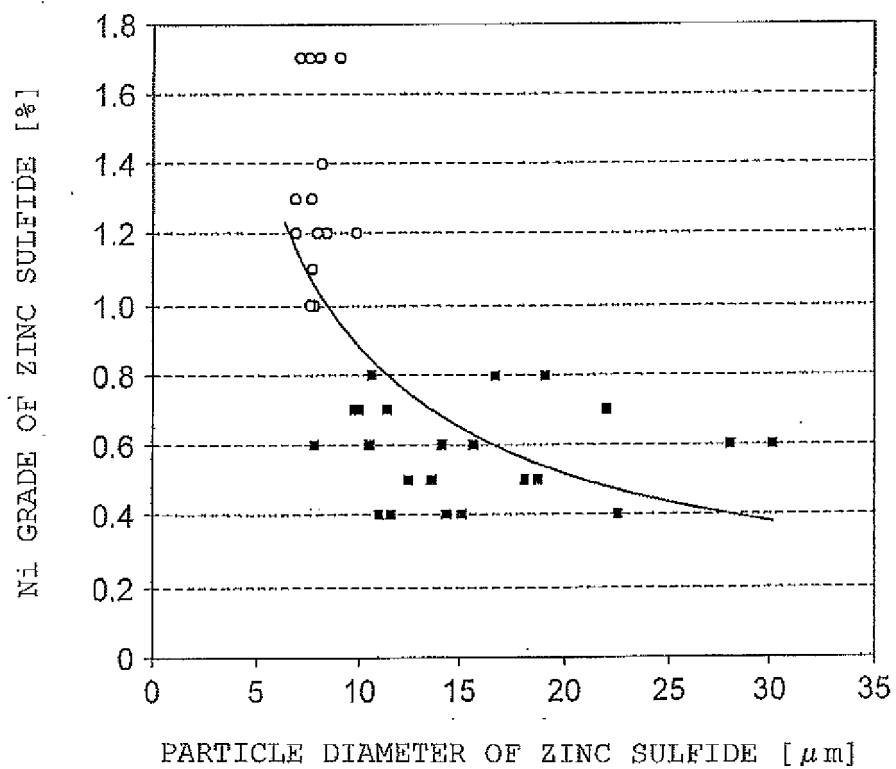


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/041381

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. C22B23/00 (2006.01) i, C22B3/06 (2006.01) i, C22B3/44 (2006.01) i

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)

Int.Cl. C22B23/00, C22B3/06, C22B3/44

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2017

Registered utility model specifications of Japan 1996-2017

Published registered utility model applications of Japan 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-305917 A (SUMITOMO METAL MINING CO., LTD.) 04 November 2004, claims, paragraphs [0035]-[0040], fig. 1 (Family: none)	1-2
A	JP 2015-028219 A (SUMITOMO METAL MINING CO., LTD.) 12 February 2015, claims, paragraph [0020], fig. 3 & US 2012/0161374 A1, claims, paragraphs [0045]-[0047], fig. 3 & WO 2011/048927 A1 & EP 2492364 A1	1-2
A	WO 2016/139858 A1 (SUMITOMO METAL MINING CO., LTD.) 09 September 2016, claims, paragraph [0037] & CA 2978233 A, claims, page 14, lines 13-25	1-2
A	JP 2010-031302 A (SUMITOMO METAL MINING CO., LTD.) 12 February 2010, claim 3, paragraph [0050] & US 2010/0018350 A1, claim 3, paragraphs [0100]-[0101]	1-2



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search
01 December 2017 (01.12.2017)Date of mailing of the international search report
12 December 2017 (12.12.2017)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010037626 A [0006]