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(54) **HYDROMETALLURGICAL PLANT FOR NICKEL OXIDE ORE AND METHOD FOR OPERATING SAID HYDROMETALLURGICAL PLANT**

(57) The present invention makes it possible to increase ore throughput and improve productivity without causing a poor reaction and a decrease in operation efficiency. A hydrometallurgical plant 10 according to the present invention includes: a leaching facility 11 provided with leaching treatment tanks 11_(n) in a plurality of lines to perform a leaching treatment; a preliminary neutralization facility 12 provided with neutralization treatment tanks in two stages to perform pH adjustment of leach slurry; and a solid-liquid separation facility 13 made up of a single line to perform solid-liquid separation of leach slurry which is pH-adjusted and discharged from the preliminary neutralization facility 12, in which the preliminary neutralization facility 12 is provided with neutralization treatment tanks 12A_(n) of a first stage in a plurality of lines so as to correspond to the respective leaching treatment tanks 11_(n), and is configured such that leach slurries which are pH-adjusted in the neutralization treatment tanks 12A_(n) of the first stage are merged in a neutralization treatment tank 12B of a second stage made up of a single line, and merged leach slurry is transported to the solid-liquid separation facility 13.

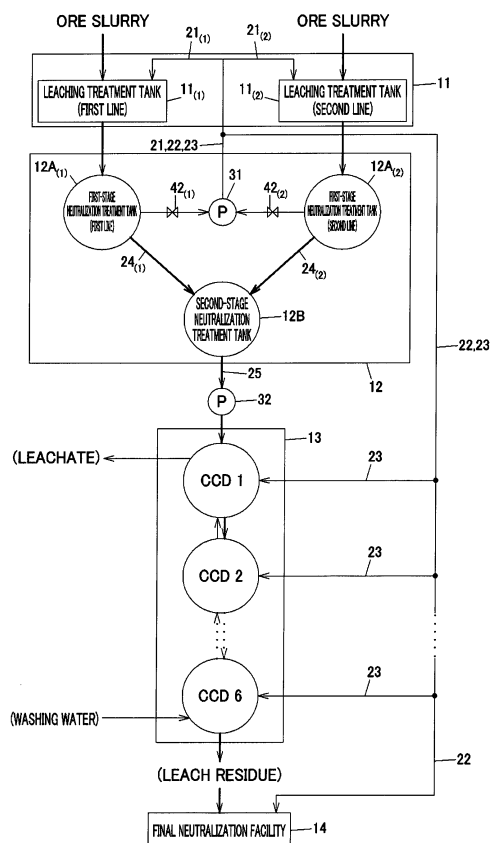


FIG.1

Description

Field of the Invention

[0001] The present invention relates to a hydrometallurgical plant for nickel oxide ores to recover nickel and cobalt from nickel oxide ores, and a method for operating the hydrometallurgical plant. The present application claims priority based on Japanese Patent Application No.2013-046986 filed in Japan on March 8, 2013. The total contents of the Patent Application are to be incorporated by reference into the present application.

Background Art

[0002] In recent years, as a hydrometallurgical process for nickel oxide ores, high pressure acid leach using sulfuric acid has been attracting attention. Unlike pyrometallurgy, which is a conventional common refining process for nickel oxide ores, the high pressure acid leach does not include pyrometallurgical steps, such as reduction and drying, but includes consistent hydrometallurgical steps, and therefore, is advantageous in terms of energy and cost. Furthermore, the high pressure acid leach has an advantage that a sulfide which contains nickel and cobalt and whose nickel grade is improved up to approximately 50% by mass (hereinafter, referred to as a "nickel-cobalt mixed sulfide" or a "Ni-Co mixed sulfide") can be obtained.

[0003] The hydrometallurgical process for nickel oxide ores which makes use of the high pressure acid leach includes steps, for example, illustrated in a schematic flowchart in Fig. 7. That is, the hydrometallurgical process includes: an ore processing step in which a nickel oxide ore is ground to a predetermined size and made into slurry; a (high pressure acid) leaching step in which sulfuric acid is added to ore slurry and made to undergo a leaching treatment under high temperature and high pressure; a preliminary neutralization step in which a neutralization (hereinafter, referred to as "preliminary neutralization") treatment is applied to leach slurry before the slurry undergoes multistage washing; a solid-liquid separation step (hereinafter, also referred to as a "CCD step") in which the leach slurry obtained by the application of the preliminary neutralization treatment is made to undergo multistage washing to be solid-liquid separated into a leach residue and a leachate containing an impurity element together with nickel and cobalt; a neutralization step in which the pH of the obtained leachate is adjusted so that a neutralization precipitate containing the impurity element is separated from the leachate, whereby a post-neutralization solution containing zinc together with nickel and cobalt is obtained; a dezincification step in which a sulfurizing agent is added to the post-neutralization solution to form a zinc sulfide and the zinc sulfide is separated therefrom, whereby a mother liquor for nickel recovery is obtained; a nickel recovery step in which a sulfurizing agent is added to the mother liquor for nickel recovery, whereby a mixed sulfide containing nickel and cobalt is formed; and a final neutralization step in which waste liquids (barren liquor) in the nickel recovery step and the residue in the CCD step are mixed and made to undergo a neutralization treatment (refer to Patent documents 1 and 2).

[0004] In the foregoing preliminary neutralization step in the hydrometallurgy, the pH of the leach slurry obtained in the leaching step is adjusted so as to make it possible to efficiently perform multistage washing in the next step, namely the CCD step. Specifically, the leach slurry is fed into a neutralization tank, and a neutralizer such as calcium carbonate is added thereto to adjust the pH of the leach slurry.

[0005] Next, in the CCD step, the leach slurry obtained after the preliminary neutralization is made to undergo multistage washing, thereby being separated into a leach residue and a leachate containing an impurity element together with nickel and cobalt. The separated leachate is sent to the neutralization step to be made into a post-neutralization solution, on the other hand, the leach residue is transported to the final neutralization step to be treated.

[0006] In the dezincification step, the post-neutralization solution is fed into a sulfurization reaction tank, and a sulfurizing agent, such as hydrogen sulfide gas or sodium hydrosulfide, is added thereto to make zinc, copper, and the like contained in the post-neutralization solution into respective sulfides. After the sulfurization treatment, solid-liquid separation is performed using a filter press or the like to obtain a mother liquor for nickel recovery from which zinc sulfide has been removed.

[0007] In the designing of a hydrometallurgical plant for nickel oxide ores, in the case where the ore throughput (or the planned production amount) of the plant is high, for example, it can be mentioned that the plant is designed based on the following two schemes. The schemes each are that: [i] a large-scale line is provided (for example, as illustrated in Fig. 8, a line with a production amount of 30,000 tons/year is provided); and [ii] two small-scale lines are provided (for example, as illustrated in Fig. 9, two lines each having a production amount of 15,000 tons/year are provided).

[0008] However, in the case of [i], particularly, in the designing of a leaching treatment facility to perform the leaching step, it is not enough to merely industrially make the size of the facility larger. That is, it is necessary to sufficiently consider a reactivity viewpoint that, in the leaching treatment facility, a predetermined leaching reaction needs to be efficiently and effectively caused to leach a valuable metal at a high leaching rate. In addition, in the case of making a facility size larger as mentioned above, there is an economic problem of an increase in repair cost as needed. Therefore,

the scheme of merely industrially making a facility size larger is practically very difficult, and hence, it is preferable to employ a conventional facility on a scale of 10,000 tons/year to 15,000 tons/year (of leach slurry production amount in terms of the amount of nickel).

[0009] Also in the case of [ii], the arrangement of a plurality of lines naturally causes an increase in the number of facilities, whereby the cost of capital investment is greatly increased. In addition, to perform an efficient refining operation, connecting piping to mutually transport a process liquid between the lines is also needed (for example, refer to Patent document 3), thereby causing a further increase in cost.

[0010] Hence, as a compromise between the foregoing schemes [i] and [ii], for example, to design a plant based on the following scheme is easily come up with. That is:

[iii] Upstream steps are made up of two lines (a plurality of lines), and subsequent downstream steps are made up of one line (for example, as illustrated in Fig. 10, upstream steps, namely the preliminary neutralization step and upstream steps therefrom, are made up of two lines (a plurality of lines), and downstream steps, namely the CCD step and downstream steps therefrom, are made up of one line, and consequently, a production amount of 30,000 tons/year is achieved).

[0011] However, it has not been known at which point in a hydrometallurgical process for nickel oxide ores steps are operationally preferably separated into the upstream steps and the downstream steps, and furthermore, a problem which is caused by merging of lines at a downstream step and affects an efficient operation has not been known.

[0012] As mentioned above, in the case where a design is made so as to separate steps into upstream steps made up of a plurality of lines and downstream steps made up of a single line, there is a possibility that property variations between process liquids (for example, leach slurries) transported from the respective lines of the upstream steps might be caused, whereby the process liquids which are not uniform are transported to the downstream steps made up of a single line. In such case, reaction conditions in treatment facilities in the downstream steps are not uniform, whereby, not only efficient operations cannot be performed, but also there is a possibility that a poor reaction and the like might be caused to have an impact on product quality.

[0013] Furthermore, there is a problem that, in one of a plurality of lines in the upstream steps, for example, in the case of the occurrence of a trouble such as poor leaching in the leaching step, or in the case of a startup operation after operational shutdown, even if no failure occurs in other lines, the whole of a plant has to be shut down because the lines are merged in the downstream step, whereby operation efficiency is considerably decreased.

[0014] For example, Patent document 3 discloses a technique being such that, in a plant having a plurality of identical process lines, treatment facilities in a predetermined step are connected to each other by piping, whereby, even in the case where a trouble or the like occurs in a facility in a predetermined step on a series of steps, a decrease in operation efficiency is kept to a minimum, and thus, this technique is operationally very effective. However, for the foregoing reason, in the case of a plant in which upstream steps are operated with two lines and the lines are merged into one line in a downstream step, the technique disclosed in Patent document 3 cannot be applied as it is.

Prior-Art Documents

Patent Documents

[0015]

Patent document 1: Japanese Patent Application Laid-Open No. H06-116660

Patent document 2: Japanese Patent Application Laid-Open No. 2005-350766

Patent document 3: Japanese Patent Application Laid-Open No. 2011-225908

Summary of the Invention

Problems to be Solved by the Invention

[0016] The present invention is proposed in view of such actual circumstances, and an object of the present invention is to provide a hydrometallurgical plant for nickel oxide ores which is capable of increasing ore throughput thereby to improve productivity without causing a poor reaction and a decrease in operation efficiency, and to provide a method for operating the hydrometallurgical plant.

Means to Solve the Problems

[0017] The present inventors earnestly studied in order to achieve the foregoing object. As a result, the inventors found that the foregoing problems can be solved in such a manner that, in a preliminary neutralization facility to apply a preliminary neutralization treatment to leach slurry obtained after a leaching treatment, neutralization treatment tanks are provided in two stages, and, neutralization treatment tanks of a first of the two stages are provided in a plurality of lines, and a neutralization treatment tank of a second of the two stages is provided in a single line.

[0018] That is, a hydrometallurgical plant for nickel oxide ores according to the present invention is characterized by including at least: a leaching facility provided with leaching treatment tanks in a plurality of lines to apply a leaching treatment to a nickel oxide ore; a preliminary neutralization facility provided with neutralization treatment tanks in two stages to perform preliminary neutralization by which pH of leach slurry discharged from the leaching treatment tanks is adjusted to a predetermined range; and a solid-liquid separation facility made up of a single line to perform solid-liquid separation of leach slurry pH-adjusted and discharged from the preliminary neutralization facility into a leachate and a leach residue in a solid-liquid separation tank, in which the preliminary neutralization facility is configured such that neutralization treatment tanks of a first of the two stages are provided in a plurality of lines so as to correspond to the respective lines of the leaching treatment tanks provided in the leaching facility, and leach slurries which are pH-adjusted in the neutralization treatment tanks constituting the first stage in the respective lines are merged in a neutralization treatment tank of a second stage made up of a single line, and leach slurry merged in the neutralization treatment tank of the second stage is transported to the solid-liquid separation facility.

[0019] A method for operating a hydrometallurgical plant for nickel oxide ores according to the present invention is a method for operating a hydrometallurgical plant to recover nickel and cobalt from a nickel oxide ore, in which the hydrometallurgical plant for nickel oxide ores includes at least: a leaching facility provided with leaching treatment tanks in a plurality of lines to apply a leaching treatment to a nickel oxide ore; a preliminary neutralization facility provided with neutralization treatment tanks in two stages to perform preliminary neutralization by which pH of leach slurry discharged from the leaching treatment tanks is adjusted to a predetermined range; and a solid-liquid separation facility made up of a single line to perform solid-liquid separation of leach slurry into a leachate and a leach residue in a solid-liquid separation tank, the leach slurry being pH-adjusted and discharged from the preliminary neutralization facility, in which, in the preliminary neutralization facility, neutralization treatment tanks of a first of the two stages are provided in a plurality of lines so as to correspond to the respective lines of the leaching treatment tanks provided in the leaching facility, and a neutralization treatment tank of a second of the two stages is made up of a single line, and leach slurries discharged from the respective neutralization treatment tanks of the first stage are merged in the neutralization treatment tank of the second stage made up of a single line, and merged leach slurry is transported to the solid-liquid separation facility.

Effects of the Invention

[0020] In the hydrometallurgical plant for nickel oxide ores according to the present invention, a preliminary neutralization facility to apply a preliminary neutralization treatment to leach slurry is made up of neutralization treatment tanks in two stages, and neutralization treatment tanks of a first of the two stages are provided in a plurality of lines so as to correspond to respective leaching treatment tanks provided in a plurality of lines, and a neutralization treatment tank of a second of the two stages is provided in a single line. This enables ore throughput to be increased while facility costs are held down, and also enables variations in leach slurry, serving as a process liquid, to be eliminated, and a poor reaction and a decrease in operation efficiency to be effectively prevented.

[0021] Furthermore, in the hydrometallurgical plant according to the present invention, neutralization treatment tanks are provided in two stages as mentioned above, and therefore, the appropriate provision of piping to connect the neutralization treatment tanks of the first stage to reaction tanks of treatment facilities in other steps enables, for example, an efficient startup operation to be performed even at the time of unusual operation such as plant startup, without adversely affecting other lines in which a normal operation can be performed and furthermore with preventing a decrease in operation efficiency.

Brief Description of the Drawings

[0022]

Fig. 1 illustrates a configuration of a hydrometallurgical plant for nickel oxide ores.

Fig. 2 is a flowchart of a hydrometallurgical process for nickel oxide ores by high pressure acid leach.

Fig. 3 illustrates an operation flow of a normal operation.

Fig. 4 illustrates an operation flow of self-circulating transport from the neutralization treatment tanks of the first stage to respective leaching treatment tanks.

Fig. 5 illustrates an operation flow to transport leach slurry from neutralization treatment tanks of the first stage to the final neutralization facility.

Fig. 6 illustrates an operation flow to transport leach slurry from neutralization treatment tanks of the first stage to solid-liquid separation tanks.

Fig. 7 is a schematic flowchart of a hydrometallurgical process by high pressure acid leaching of nickel oxide ores.

Fig. 8 is a schematic flowchart of a hydrometallurgical process by high pressure acid leaching of nickel oxide ores.

Fig. 9 is a schematic flowchart of a hydrometallurgical process by high pressure acid leaching of nickel oxide ores.

Fig. 10 is a schematic flowchart of a hydrometallurgical process by high pressure acid leaching of nickel oxide ores.

Detailed Description of the Invention

[0023] Hereinafter, with reference to the drawings, a hydrometallurgical plant for nickel oxide ores and a method for operating the hydrometallurgical plant according to the present invention will be described in detail in the following order. It should be noted that the present invention is not limited to the following embodiment, and various changes can be made within the scope not deviating from the gist of the present invention.

1. Outline of hydrometallurgical plant for nickel oxide ores

2. Hydrometallurgy for nickel oxide ores

3. Configuration of hydrometallurgical plant and method for operating hydrometallurgical plant

3-1. Basic configuration and operation flow of normal operation

3-2. Configuration for self-circulation and operation flow of self-circulation

3-3. Configuration for transport to final neutralization facility, and operation flow of transport to final neutralization facility

3-4. Configuration for transport to solid-liquid separation tank, and operation flow of transport to solid-liquid separation tank

3-5. Shift from unusual operation to normal operation

3-6. Conclusion

4. Examples

«1. Outline of hydrometallurgical plant for nickel oxide ores»

[0024] The hydrometallurgical plant for nickel oxide ores according to the present embodiment (hereinafter, also simply referred to as "hydrometallurgical plant") is a plant to perform a hydrometallurgical operation for nickel oxide ores, the operation including, for example, a leaching step by high pressure acid leach, a preliminary neutralization step, a solid-liquid separation step (CCD step), a neutralization step, a dezincification step, a sulfurization step, and a final neutralization step (detoxification step).

[0025] Specifically, as illustrated in the configuration of a hydrometallurgical plant in Fig. 1, a hydrometallurgical plant 10 according to the present invention includes at least: a leaching facility 11 provided with leaching treatment tanks $11_{(1 \text{ to } n)}$ in a plurality (n) of lines to apply a leaching treatment to a nickel oxide ore; a preliminary neutralization facility 12 provided with neutralization treatment tanks in two stages to perform preliminary neutralization by which the pH of leach slurries discharged from the leaching treatment tanks $11_{(1 \text{ to } n)}$ are adjusted to a predetermined range; and a solid-liquid separation facility 13 made up of a single line to perform the solid-liquid separation of leach slurry which is pH-adjusted and discharged from the preliminary neutralization facility 12 in solid-liquid separation tanks.

[0026] Furthermore, in the hydrometallurgical plant 10, the foregoing preliminary neutralization facility 12 is configured such that neutralization treatment tanks $12A_{(1 \text{ to } n)}$ of a first of the two stages is provided in a plurality (n) of lines so as to correspond to the respective lines of the leaching treatment tanks $11_{(1 \text{ to } n)}$ provided in the leaching facility, and leach slurries which are pH-adjusted in the neutralization treatment tanks $12A_{(1 \text{ to } n)}$ of the first stage in the respective lines are merged in a neutralization treatment tank 12B of a second of the two stages which is made up of a single line. Then, leach slurry merged in the neutralization treatment tank 12B of the second stage is transported to the solid-liquid separation facility 13.

[0027] It should be noted that Fig. 1 illustrates a specific example of a plant configuration in which the leaching treatment tanks $11_{(1 \text{ to } n)}$ and the neutralization treatment tanks $12A_{(1 \text{ to } n)}$ of the first stage are provided in two lines ($n = 2$), but the number of the lines are not limited to two.

[0028] As mentioned above, the hydrometallurgical plant 10 is configured such that, in the preliminary neutralization step and steps upstream therefrom (hereinafter, also referred to as "upstream steps"), a series of treatment facilities is provided with reaction tanks in two or more lines, and, in steps downstream from the preliminary neutralization step

(hereinafter, also referred to as "downstream steps"), a series of treatment facilities is provided with reaction tanks in a single line (one line). Such configuration enables an increase in nickel oxide ore throughput, thereby enabling the production amount of a nickel-cobalt mixed sulfide (a product) to be stably increased, while reducing the number of parts and reducing facility costs, by using a leaching treatment facility of a size which has a track record of being operated.

[0029] Furthermore, according to the hydrometallurgical plant 10, leach slurries obtained from the treatment facilities in a plurality of lines are merged in the neutralization treatment tank 12B of the second stage, and therefore, even if variations in the pH and the like of the leach slurries arise, the variations can be eliminated, and thus a solid-liquid separation treatment can be applied to uniform leach slurry in the solid-liquid separation facility 13.

[0030] Furthermore, according to the hydrometallurgical plant 10, piping to connect the neutralization treatment tanks 12A_(1 to n) of the first stage to reaction tanks of treatment facilities in other steps is appropriately provided, whereby, for example, leach slurry in a state where a leaching treatment performed immediately after a plant operation startup or the like does not sufficiently proceed yet can be prevented from being transported to the solid-liquid separation step and steps downstream therefrom. This enables effective prevention of a poor reaction and a decrease in operation efficiency in the each step.

[0031] Hereinafter, more specifically, the hydrometallurgical plant for nickel oxide ores and the method for operating the hydrometallurgical plant according to the present embodiment will be described.

«2. Hydrometallurgy for nickel oxide ores»

[0032] First, a hydrometallurgical process for nickel oxide ores which is performed by the hydrometallurgical plant 10 according to the present embodiment will be described. This hydrometallurgical process for nickel oxide ores is a hydrometallurgical process by which nickel and cobalt are leached out and recovered from a nickel oxide ore by using, for example, high pressure acid leach (HPAL).

[0033] Fig. 2 illustrates an example of a flowchart (a process chart) of a hydrometallurgical process for nickel oxide ores by using high pressure acid leach. As illustrated in Fig. 2, the hydrometallurgical process for nickel oxide ores includes: a leaching step S 1 in which sulfuric acid is added to slurry of nickel oxide ore and a leaching treatment is applied to the slurry under high temperature and high pressure; a preliminary neutralization step S2 in which preliminary neutralization is performed to adjust the pH of obtained leach slurry to a predetermined range; a solid-liquid separation step S3 in which multistage washing is applied to pH-adjusted leach slurry to separate a residue therefrom, whereby a leachate containing an impurity element together with nickel and cobalt is obtained; a neutralization step S4 in which the pH of the leachate is adjusted to separate a neutralization precipitate containing the impurity element therefrom, whereby a post-neutralization solution containing zinc together with nickel and cobalt is obtained; a dezincification step 5 in which a sulfurizing agent is added to the post-neutralization solution to form a zinc sulfide, and the zinc sulfide is separated and removed therefrom to obtain a mother liquor for nickel recovery which contains nickel and cobalt; and a nickel recovery step S6 in which a sulfurizing agent is added to the mother liquor for nickel recovery to form a mixed sulfide containing nickel and cobalt. This hydrometallurgical process further includes a final neutralization step 7 in which a leach residue separated in the solid-liquid separation step S3 and a barren liquor discharged in the nickel recovery step S6 are recovered and rendered harmless.

(1) Leaching step

(1-1) Leaching treatment

[0034] In the leaching step S 1, a leaching treatment using, for example, high pressure acid leach is applied to a nickel oxide ore. Specifically, sulfuric acid is added to ore slurry obtained by grinding a nickel oxide ore serving as a raw material, and the ore slurry is pressurized under a high temperature of 220 C° to 280 C° to be agitated, whereby leach slurry including a leachate and a leach residue is formed.

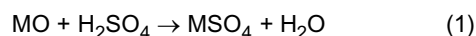
[0035] As the nickel oxide ore used in the leaching step S 1, what is called laterite ore, such as limonite ore or saprolite ore, is mainly used. The nickel content of a laterite ore is usually 0.8% to 2.5% by weight, and the nickel is contained in the form of hydroxide or magnesium silicate mineral. Furthermore, the iron content of the laterite ore is 10% to 50% by weight, and the iron is contained mainly in the form of trivalent hydroxide (goethite), but, a magnesium silicate mineral contains some divalent iron. Furthermore, in the leaching step S1, besides such laterite ore, an oxide ore containing valuable metals, such as nickel, cobalt, manganese, and copper, for example, a manganese lump present in a deep seabed is used.

[0036] In the leaching treatment in this leaching step S1, leaching reactions expressed by the following formulas (1) to (3) and high temperature hydrolysis reactions expressed by the following formulas (4) and (5) occur, whereby nickel, cobalt, and the like are leached out in the form of sulfate and a leached-out iron sulfate is fixed as hematite. It should be noted that, since the fixation of iron ions does not completely proceed, besides nickel, cobalt, and the like, divalent

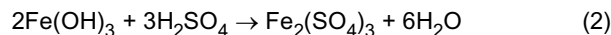
and trivalent iron ions are usually contained in a liquid portion of obtained leach slurry.

· Leaching reaction

[0037]

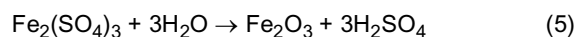
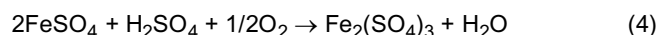


(where M in the formula represents Ni, Co, Fe, Zn, Cu, Mg, Cr, Mn, or the like.)



· High temperature hydrolysis reaction

[0038]



[0039] The amount of sulfuric acid added in the leaching step S 1 is not particularly limited, but sulfuric acid is added in an excessive amount so as to leach out iron contained in the ore. For example, 300 to 400 kg of sulfuric acid is added per ton of ore. When the amount of sulfuric acid added per ton of ore is more than 400 kg, sulfuric acid cost becomes higher, which is not preferable. It should be noted that, from a viewpoint of filterability of a hematite-containing leach residue to be formed in a subsequent step, namely the solid-liquid separation step S3, an adjustment is preferably performed in the leaching step S 1 so that an obtained leachate has a pH of 0.1 to 1.0.

(1-2) Leaching facility

[0040] In the hydrometallurgical plant 10 according to the present embodiment, the leaching treatment in the foregoing leaching step S 1 is performed in the leaching facility (high pressure acid leaching facility) 11.

[0041] Specifically, as illustrated in Fig. 1, the leaching facility 11 in this hydrometallurgical plant 10 is provided with the leaching treatment tanks $11_{(1 \text{ to } n)}$ in a plurality (n) of lines (for example, $n = 2$ lines as illustrated in Fig. 1) to apply the leaching treatment to a nickel oxide ore. It should be noted that, hereinafter, the leaching treatment tank will be expressed as the "leaching treatment tank $11_{(n)}$ ", unless the number of lines is not specified. Furthermore, likewise, the later-mentioned neutralization treatment tanks $12A_{(1 \text{ to } n)}$ of the first stage will be expressed as the "neutralization treatment tanks $12A_{(n)}$ ".

[0042] As the leaching treatment tanks $11_{(n)}$ in the lines constituting the leaching facility 11, for example, a high temperature pressurizing vessel (autoclave) is employed. Into the leaching treatment tanks $11_{(n)}$, for example, ore slurry transported from an ore processing step, that is, a predetermined amount of ore slurry obtained by grinding an ore to a predetermined particle diameter is fed from inlet portions of the leaching treatment tanks $11_{(n)}$.

[0043] The size of the leaching treatment tanks $11_{(n)}$ each made up of an autoclave and the like is not particularly limited, but there may be employed a leaching treatment tank having a size equivalent to that of a leaching treatment tank which has been conventionally employed for operations. For example, there may be employed a leaching treatment tank on a scale of 10,000 tons/year to 20,000 tons/year of leach slurry production amount in terms of the amount of nickel. As mentioned above, the use of a leaching facility provided with conventional leaching treatment tanks in a plurality of lines enables an increase in nickel oxide ore throughput, thereby enabling the production amount of a nickel-cobalt mixed sulfide obtained through downstream steps to be increased.

[0044] Here, although details will be mentioned later, piping 21 (n) to connect the leaching treatment tank $11_{(n)}$ to the neutralization treatment tank $12A_{(n)}$ of the first stage, the tank $12A_{(n)}$ being a constituent of the preliminary neutralization facility 12, may be connected to an inlet portion of the leaching treatment tank $11_{(n)}$. This piping 21_(n) is piping to connect the leaching treatment tank $11_{(n)}$ and the neutralization treatment tank $12A_{(n)}$ of the first stage which are in the same line. This piping 21_(n) is what is called piping for self-circulation which makes it possible that circulating (self-circulating) transport of leach slurry discharged from the neutralization treatment tank $12A_{(n)}$ of the first stage to the leaching treatment tank 11 (n) in the same line is performed by a transport pump 31. It should be noted that an operation for the self-

circulation will be described later in detail.

(2) Preliminary neutralization step

(2-1) Preliminary neutralization treatment

[0045] In the preliminary neutralization step S2, the pH of leach slurry obtained in the leaching step S1 is adjusted to a predetermined range. In the leaching step S 1 of performing the foregoing leaching treatment by high pressure acid leach, an excessive amount of sulfuric acid is added from a viewpoint of improving a leaching rate. Therefore, obtained leach slurry contains free sulfuric acid (surplus sulfuric acid not having involved in a leaching reaction), and has a very low pH. Hence, in the preliminary neutralization step S2, the pH of leach slurry is adjusted to a predetermined range so that, at the time of multistage washing in the subsequent step, namely the solid-liquid separation step S3, washing is efficiently performed.

[0046] Specifically, leach slurry to be subjected to washing treatment preferably has an adjusted pH of 2 to 6. When the leach slurry has a pH lower than 2, the cost of making facilities in downstream steps acid-resistant is needed. On the other hand, when the leach slurry has a pH higher than 6, there is a possibility that nickel which is leached out into a leachate (slurry) remains as a residue (precipitated) in the process of washing, whereby washing efficiency is reduced. It should be noted that, in practical operations, an appropriate pH value may be selected within the foregoing pH range, based on the operational status of the leaching treatment in the leaching step S 1 and the conditions of the pH of washing water to be used in the solid-liquid separation step S3 (in the case of acid rain, the pH is approximately 5) and the like.

[0047] A method for adjusting pH is not particularly limited, but, for example, the addition of a neutralizer such as calcium carbonate slurry enables pH to be adjusted to a predetermine range.

(2-2) Preliminary neutralization facility

[0048] In the hydrometallurgical plant 10 according to the present embodiment, the foregoing preliminary neutralization treatment in the preliminary neutralization step S2 is performed in the preliminary neutralization facility 12.

[0049] Specifically, as illustrated in Fig. 1, the preliminary neutralization facility 12 in this hydrometallurgical plant 10 is provided with neutralization treatment tanks 12A and 12B in two stages. Furthermore, of the neutralization treatment tanks 12A and 12B in two stages, the neutralization treatment tanks 12A_(n) of a first of the two stages are provided in a plurality (n) of lines so as to correspond to the respective lines of the leaching treatment tanks 11_(n) provided in the foregoing leaching facility 11. On the other hand, the neutralization treatment tank 12B of a second of the two stages is provided in a single line, and it is configured such that leach slurries discharged from the neutralization treatment tanks 12A_(n) of the first stage are merged in the neutralization treatment tank 12B of the second stage.

[0050] For example, in the case where the leaching facility 11 is provided with leaching treatment tanks (a leaching treatment tank 11₍₁₎, a leaching treatment tank 11₍₂₎) in two lines, a neutralization treatment tank 12A₍₁₎ and a neutralization treatment tank 12A₍₂₎ are provided as the neutralization treatment tanks 12A of the first stage so as to correspond to leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively. Furthermore, the neutralization treatment tank 12B of the second stage is made up of a treatment tank in a single line, and leach slurries discharged from the neutralization treatment tank 12A₍₁₎ and the neutralization treatment tank 12A₍₂₎ of the first stage are merged in the neutralization treatment tank 12B of the second stage.

[0051] Here, in a normal operation, there easily arise variations in, for example, the pH of post-preliminary-neutralization slurries obtained by the preliminary neutralization of leach slurries by using neutralization treatment tanks in a plurality of lines, and thus, the leach slurries obtained from the neutralization treatment tanks in the respective lines are not uniform. In the case where treatments in steps downstream from the preliminary neutralization step are performed using such leach slurries whose properties are not uniform between the lines, variations in reaction and the like arise, whereby an efficient operation cannot be performed.

[0052] Therefore, as mentioned above, in the present embodiment, the preliminary neutralization facility 12 is provided with the neutralization treatment tanks 12A and 12B in two stages, and steps are divided into upstream step and downstream steps at a boundary between a first and a second of the two stages, and a plurality of lines are provided up to the neutralization treatment tanks 12A_(n) of the first stage, and the lines are merged in the neutralization treatment tank 12B of the second stage. In such configuration, leach slurries are merged in the neutralization treatment tank 12B of the second stage, and thus variations between slurries can be eliminated, whereby uniform leach slurry can be transported to the subsequent step, namely the solid-liquid separation step S3. Furthermore, this neutralization treatment tank 12B of the second stage can be made to work as a residence tank (buffer), and therefore, the flow rate of leach slurry can be appropriately adjusted and stably transported to the solid-liquid separation step S3.

[0053] Furthermore, the provision of the leaching treatment tanks 11_(n) in a plurality of lines in the leaching step S1 leads to an increase in nickel oxide ore throughput, and the integration (merging) of the plurality of lines in the subsequent

step, namely the preliminary neutralization step S2 achieves the merging of the lines at an earlier stage after the leaching treatment, whereby the number of parts of facilities constituting the plant can be reduced. As mentioned above, in the hydrometallurgical plant 10 according to the present embodiment, while the number of the parts is reduced to reduce facility costs effectively, nickel oxide ore throughput can be effectively increased.

[0054] A specific neutralization method in this preliminary neutralization facility 12 is such that low-pH leach slurries obtained from the leaching treatment tanks $11_{(n)}$ in the lines are fed into the neutralization treatment tanks $12A_{(n)}$ of the first stage which correspond to the respective lines, and for example, a neutralizer such as calcium carbonate slurry is added thereto to neutralize the leach slurries. After that, the leach slurries neutralized in the neutralization treatment tanks $12A_{(n)}$ of the first stage in the respective lines are merged in the neutralization treatment tank 12B of the second stage, whereby a post-preliminary-neutralization leach slurry is obtained. It should be noted that, also in the neutralization treatment tank 12B of the second stage, a neutralizer may be added to make fine adjustments of pH of the leach slurry. This addition enables pH-adjusted leach slurry to be more stably subjected to a solid-liquid separation treatment.

[0055] Here, to the neutralization treatment tank $12A_{(n)}$ of the first stage in the preliminary neutralization facility 12, the piping $21_{(n)}$ to connect the neutralization treatment tank $12A_{(n)}$ to the leaching treatment tank $11_{(n)}$ in the leaching facility 11 may be connected. This piping $21_{(n)}$ is piping to connect the neutralization treatment tank $12A_{(n)}$ of the first stage and an inlet portion of the leaching treatment tank $11_{(n)}$ which are in the same line. This piping $21_{(n)}$ is what is called piping for self-circulation which makes it possible to perform circulating (self-circulating) transport of leach slurry from the neutralization treatment tank $12A_{(n)}$ of the first stage to the leaching treatment tank $11_{(n)}$ in the same line by using a transport pump 31. It should be noted that the arrangement configuration of the piping $21_{(n)}$ and an operation for the self-circulation will be described later in detail.

[0056] Furthermore, to the neutralization treatment tanks $12A_{(n)}$ of the first stage in the preliminary neutralization facility 12, piping 22 to connect the neutralization treatment tanks $12A_{(n)}$ and a final neutralization facility 14 in the final neutralization step (detoxification step) S7 can be connected. This piping 22 is led individually from the neutralization treatment tanks $12A_{(n)}$ of the first stage in the respective lines and connected to an inlet portion of the final neutralization facility 14, or the piping 22 led from the respective lines is united at a predetermined point and connected to an inlet portion of the final neutralization facility 14, and the transport pump 31 provided in the piping 22 makes it possible that leach slurry discharged from the neutralization treatment tanks $12A_{(n)}$ of the first stage is transported to the final neutralization facility 14. It should be noted that an arrangement configuration of the piping 22 and an operation for transporting leach slurry from the neutralization treatment tanks $12A_{(n)}$ of the first stage to the final neutralization facility 14 will be described later in detail.

[0057] Furthermore, to the neutralization treatment tanks $12A_{(n)}$ of the first stage in the preliminary neutralization facility 12, piping 23 to connect the neutralization treatment tanks $12A_{(n)}$ to solid-liquid separation tanks provided in multiple stages in the solid-liquid separation facility 13 for the solid-liquid separation step S3 can be connected. This piping 23 is led individually from the neutralization treatment tanks $12A_{(n)}$ of the first stage in the respective lines and connected to inlet portions of the solid-liquid separation tanks provided in multiple stages, or the piping 23 led from the respective lines is united at a predetermined point and connected to inlet portions of the solid-liquid separation tanks provided in multiple stages, and the transport pump 31 provided in the piping 23 makes it possible that leach slurry discharged from the neutralization treatment tanks $12A_{(n)}$ of the first stage is transported to a predetermined solid-liquid separation tank. It should be noted that an arrangement configuration of the piping 23 and an operation for transporting the leach slurry from the neutralization treatment tanks $12A_{(n)}$ of the first stage to a predetermined solid-liquid separation tank will be described later in detail.

[0058] It should be noted that Fig. 1 illustrates an aspect in which the foregoing pipings 21, 22, and 23 are partly shared as common piping, and furthermore, a transport pump to transport leach slurry is shared, but the present invention is not limited to this aspect. The pipings 21, 22, and 23 may be individually provided, and each of the pipings 21, 22, and 23 may be provided with a transport pump.

(3) Solid-liquid separation step

(3-1) Solid-liquid separation treatment

[0059] In the solid-liquid separation step S3, multistage washing is applied to pH-adjusted leach slurry obtained in the preliminary neutralization step S2, whereby a leach residue and a leachate containing zinc as an impurity element besides nickel and cobalt (a crude nickel sulfate solution) are separated.

[0060] In the solid-liquid separation step S3, for example, leach slurry is mixed with a washing liquid, and then, a solid-liquid separation treatment is applied thereto using a solid-liquid separation apparatus such as a thickener and using a flocculant supplied from a flocculant supply apparatus or the like. Specifically, first, leach slurry is diluted by a washing liquid, and then, a leach residue in the slurry is condensed as a precipitate by a thickener. This allows the amount of nickel adhering to the leach residue to be reduced depending on the degree of the dilution.

[0061] In this solid-liquid separation step S3, it is preferable that, using solid-liquid separation tanks, such as thickeners, which are connected in multiple stages, multistage washing is applied to leach slurry to perform solid-liquid separation. Specifically, as a multistage washing method, there may be employed a counter current decantation (CCD) to bring leach slurry into contact with a countercurrent of a washing liquid. Thus, a washing liquid to be newly introduced in the

[0062] The washing liquid (washing water) is not particularly limited, but a washing liquid which contains no nickel and does not affect the step is preferably used. Among such washing liquids, a washing liquid having a pH of 1 to 3 is preferably used. This is because, in the case where aluminum is contained in a leachate, a washing liquid having a high pH causes the formation of a bulky aluminum hydroxide, thereby leading to poor sedimentation of a leach residue. Hence, it is beneficial that, as the washing liquid, a barren liquor having a low pH (a pH of approximately 1 to 3) which is obtained by the nickel recovery step S6 as a downstream step is repeatedly used.

[0063] The flocculant to be used is not particularly limited, and, for example, an anionic flocculant may be used.

(3-2) Solid-liquid separation facility

[0064] In the hydrometallurgical plant 10 according to the present embodiment, the foregoing solid-liquid separation treatment in the solid-liquid separation step S3 is performed in the solid-liquid separation facility 13.

[0065] Specifically, as illustrated in Fig. 1, thickeners (solid-liquid separation tanks) (CCD1 to CCD6) are connected in six stages to constitute the solid-liquid separation facility 13 in the hydrometallurgical plant 10. To this solid-liquid separation facility 13, (pH-adjusted) leach slurry obtained after preliminary neutralization in the preliminary neutralization step S2 is transported by a transport pump, and fed into a thickener (CCD1) of a first of the six stages. On the other hand, washing liquid (washing water) is fed into a thickener of a last stage, namely a thickener (CCD6) of a sixth of the six stages via not-illustrated piping.

[0066] In this solid-liquid separation facility 13, in the process of transport of the leach slurry fed into CCD1 from CCD1 to CCD2, CCD3, ... and CCD6 in this order, contact of the leach slurry with a countercurrent of a washing liquid fed into CCD6 and the aggregation of a residue in the leach slurry are repeated, whereby a leachate adhering to the residue is washed. By this operation, a residue containing valuable metals such as nickel and having little leachate is discharged from the thickener CCD6 of the last stage. Specifically, the concentration of nickel in moisture adhering to the residue is almost 0 g/L, and thus, a residue washed to have the nickel concentration of approximately 0.5 g/L at the maximum is discharged. The discharged residue is transported to the final neutralization step S7 to be rendered harmless.

[0067] On the other hand, in the process of transport of the washing liquid fed into CCD6 of the last stage from CCD6 to CCD5, CCD4, ... and CCD1 in this order, the washing liquid takes in moisture adhering to a residue in leach slurry. Accordingly, the concentration of valuable metals such as nickel in the washing liquid increases, and, finally, the washing liquid is discharged as a leachate from CCD1, and transported to the subsequent step, namely the neutralization step S4. Specifically, as for the concentration of valuable metals in the washing liquid fed into CCD6, for example, the concentration of nickel is approximately 0 g/L at the time of the feeding, and gradually increases to approximately 0.5 g/L in the process of the transport from CCD6 to CCD5, and increases to approximately 1 g/L in the process of the transport from CCD5 to CCD4, and finally a leachate discharged from CCD 1 has a nickel concentration of approximately 3 g/L.

[0068] It should be noted that, in the foregoing example, solid-liquid separation tanks such as thickeners are connected in six stages to be provided, but the number of connected stages is not limited to this, and may be suitably determined in consideration of an installation space in the hydrometallurgical plant, product specifications, throughput capacity in a subsequent step and downstream steps therefrom, and the like. Furthermore, a desired concentration of valuable metals in a leachate to be recovered is preferably suitably determined likewise. Furthermore, also the concentration of nickel in a liquid phase of each of the thickeners (CCD) constituting the solid-liquid separation facility 13 is not limited to the foregoing concentration.

[0069] Here, as mentioned above, to inlet portions of solid-liquid separation tanks such as thickeners provided in multiple stages, piping 23 to connect the solid-liquid separation tanks to the neutralization treatment tanks 12A_(n) of the first stage which constitute the preliminary neutralization facility 12 can be connected. This piping 23 is led individually from the neutralization treatment tanks 12A_(n) of the first stage in the respective lines and connected to inlet portions of the solid-liquid separation tanks provided in multiple stages, or the piping 23 led from the respective lines is united at a predetermined point and connected to inlet portions of the solid-liquid separation tanks provided in multiple stages, and a transport pump 31 provided in the piping 23 makes it possible that leach slurry discharged from the neutralization treatment tanks 12A_(n) of the first stage is transported to a predetermined solid-liquid separation tank. It should be noted that an arrangement configuration of the piping 23 and an operation for transporting leach slurry from the neutralization treatment tanks 12A_(n) of the first stage to a predetermined solid-liquid separation tank will be described later in detail.

(4) Neutralization step

[0070] In the neutralization step S4, the pH of a leachate (a crude nickel sulfate solution) separated in the solid-liquid separation step S3 is adjusted, whereby a neutralization precipitate containing an impurity element is separated therefrom to obtain a post-neutralization solution containing zinc together with nickel and cobalt.

[0071] Specifically, in the neutralization step S4, while oxidation of the separated leachate is prevented, a neutralizer such as calcium carbonate is added to the leachate so as to adjust the pH of an obtained post-neutralization solution to not more than 4, preferably to from 3.0 to 3.5, more preferably to from 3.1 to 3.2, whereby the post-neutralization solution and neutralization precipitate slurry which contains trivalent iron as an impurity element are formed. Thus, in the neutralization step S4, impurities, such as trivalent iron ions and aluminum ions, which remain in the solution are removed as a neutralization precipitate, whereby the post-neutralization solution to serve as a source of a mother liquor for nickel recovery is formed.

[0072] The neutralization treatment in the neutralization step S4 is performed by a neutralization facility. The neutralization facility is provided with, for example, a neutralization reaction tank to perform a neutralization reaction and a separation treatment tank such as a thickener to separate a neutralization precipitate and a post-neutralization solution which are obtained by a neutralization reaction. This neutralization facility is made up of a single line. In the neutralization reaction tank of the neutralization facility, a leachate (a crude nickel sulfate solution) discharged from CCD 1 of the foregoing solid-liquid separation facility 13 is fed, and a neutralizer such as calcium carbonate is charged, whereby a neutralization reaction is caused. Furthermore, in the separation treatment tank, slurry after a neutralization reaction is fed, and the slurry is separated into a post-neutralization solution to serve as a mother liquor for nickel recovery and neutralization precipitate slurry which contains trivalent iron as an impurity element. In this separation treatment tank, the neutralization precipitate slurry is extracted from the bottom of the separation treatment tank. On the other hand, the post-neutralization solution from which the neutralization precipitate is separated overflows into a storage tank or the like to be stored, and then is transported to the subsequent step, namely the dezincification step S5.

(5) Dezincification step

[0073] In the dezincification step S5, a sulfurizing agent such as hydrogen sulfide gas is added to the post-neutralization solution obtained by the neutralization step S4 to perform a sulfurization treatment, whereby a zinc sulfide is formed, and the zinc sulfide is separated and removed to obtain a mother liquor for nickel recovery which contains nickel and cobalt (a post-dezincification solution).

[0074] Specifically, for example, the post-neutralization solution containing zinc together with nickel and cobalt is introduced into a pressurized vessel, and hydrogen sulfide gas or the like is blown into a gas phase thereof, whereby zinc is selectively sulfurized in contrast to nickel and cobalt, and thus, a zinc sulfide and a mother liquor for nickel recovery are formed.

[0075] The dezincification treatment in the dezincification step S5 is performed in a dezincification facility. The dezincification facility includes, for example: a sulfurization reaction tank to perform a sulfurization reaction by blowing hydrogen sulfide gas or the like into the post-neutralization solution; and a filter device to separate and remove zinc sulfide from a post-sulfurization-reaction solution. This dezincification facility is made up of a single line. Into the sulfurization reaction tank of the dezincification facility, the post-neutralization solution transported through the foregoing neutralization step S4 is fed, and a sulfurizing agent such as hydrogen sulfide gas is blown, whereby a sulfurization reaction is caused. Furthermore, the filter device is made up of a filter cloth and the like, and separates zinc sulfide from a post-sulfurization-reaction solution containing zinc sulfide to form a mother liquor for nickel recovery. The obtained mother liquor for nickel recovery is transported to the subsequent nickel recovery step S6.

(6) Nickel recovery step

[0076] In the nickel recovery step S6, a sulfurizing agent such as hydrogen sulfide gas is blown into the mother liquor for nickel recovery which is obtained by separating and removing zinc as an impurity element in the form of zinc sulfide in the dezincification step S5, whereby a sulfurization reaction is caused to form a sulfide containing nickel and cobalt (a nickel-cobalt mixed sulfide) and a barren liquor.

[0077] The mother liquor for nickel recovery is a sulfuric acid solution obtained by reducing an impurity component in a leachate of nickel oxide ore through the neutralization step S4 and the dezincification step S5. It should be noted that there is a possibility for approximately a few g/L of iron, magnesium, manganese, and the like to be contained as impurity components in this mother liquor for nickel recovery, but, these impurity components have lower stability as a sulfide, compared to nickel and cobalt which are to be recovered, and hence, the impurity components are not contained in a formed sulfide.

[0078] The nickel recovery treatment in the nickel recovery step S6 is performed in a nickel recovery facility. The nickel

recovery facility includes, for example: a sulfurization reaction tank to perform a sulfurization reaction by blowing hydrogen sulfide gas or the like into the mother liquor for nickel recovery; and a solid-liquid separation tank to separate and recover a nickel-cobalt mixed sulfide from a post-sulfurization-reaction solution. This nickel recovery facility is made up of a single line. Into the sulfurization reaction tank of the nickel recovery facility, the mother liquor for nickel recovery transported through the foregoing dezincification step S5 is fed and a sulfurizing agent such as hydrogen sulfide gas is blown, whereby a sulfurization reaction is caused to form a nickel-cobalt mixed sulfide. Furthermore, the solid-liquid separation tank is made up of, for example, a thickener and the like, and is configured to apply a sedimentation and separation treatment to post-sulfurization-reaction slurry containing the nickel-cobalt mixed sulfide, thereby separating and recovering the nickel-cobalt mixed sulfide as a sediment from a bottom portion of the thickener. On the other hand, an aqueous solution component is made to overflow, thereby being recovered as a barren liquor.

[0079] It should be noted that the recovered barren liquor is a solution having a very low concentration of valuable metals such as nickel, and contains impurity elements, such as iron, magnesium, and manganese, which remain without being sulfurized. This barren liquor is transported to the final neutralization step S7 to be rendered harmless.

(7) Final neutralization step

(7-1) Final neutralization treatment

[0080] In the final neutralization step S7, the leach residue discharged from a solid-liquid separation tank of the last stage (for example, CCD6) out of the tanks provided in multiple stages in the foregoing solid-liquid separation treatment in the solid-liquid separation step S3; a barren liquor containing impurity elements, such as iron, magnesium, and manganese, and recovered in the nickel recovery step S6; and the like are made to undergo a neutralization treatment (detoxication treatment), thereby being adjusted to have a pH in a predetermined range which meets an effluent standard.

[0081] A method for the pH adjustment is not particularly limited, but, for example, pH can be adjusted to the predetermined range by the addition of a neutralizer such as calcium carbonate slurry.

(7-2) Final neutralization facility

[0082] In the hydrometallurgical plant 10 according to the present embodiment, the foregoing neutralization treatment in the final neutralization step S7 is performed in the final neutralization facility 14.

[0083] Specifically, as the final neutralization facility 14 in this hydrometallurgical plant 10, for example, a final neutralization treatment tank is provided in a single line. Specifically, into the final neutralization facility 14, the leach residues transported through the foregoing solid-liquid separation step S3 and the barren liquor transported through the nickel recovery step S6 are fed. Then, in the reaction tank, while the leach residues and the barren liquor are mixed, the pH of a mixture thereof is adjusted to a predetermined range by a neutralizer, whereby waste slurry (tailings) is formed. The tailings formed in this reaction tank are transported to a tailings dam (waste storage).

[0084] Here, as mentioned above, to an inlet portion of the final neutralization facility 14, piping 22 to connect the final neutralization facility 14 to the neutralization treatment tanks 12A_(n) of the first stage which are constituents of the preliminary neutralization facility 12 can be connected. This piping 22 is led individually from the neutralization treatment tanks 12A_(n) of the first stage in the respective lines and connected to the inlet portion of the final neutralization facility 14, or the piping 22 led from the respective lines is united at a predetermined point and connected to the inlet portion of the final neutralization facility 14, and a transport pump 31 provided in the piping 22 makes it possible that leach slurry discharged from the neutralization treatment tanks 12A_(n) of the first stage is transported to the final neutralization facility 14. It should be noted that an arrangement configuration of the piping 22 and an operation for transporting the leach slurry from the neutralization treatment tanks 12A_(n) of the first stage to the final neutralization facility 14 will be described later in detail.

«3. Configuration of hydrometallurgical plant and method for operating hydrometallurgical plant»

<3-1. Basic configuration and operation flow of normal operation>

<3-1-1. Basic configuration>

[0085] As mentioned above, the hydrometallurgical plant 10 according to the present embodiment includes at least: the leaching facility 11 provided with the leaching treatment tanks 11_(n) in a plurality (n) of lines to apply a leaching treatment to a nickel oxide ore; the preliminary neutralization facility 12 provided with the neutralization treatment tanks 12A and 12B in two stages to perform preliminary neutralization by which the pH of leach slurries discharged from the leaching treatment tanks 11_(n) is adjusted to a predetermined range; and the solid-liquid separation facility 13 made up

of a single line to perform solid-liquid separation of leach slurry pH-adjusted and discharged from the preliminary neutralization facility 12 in a solid-liquid separation tank (Fig. 1).

[0086] Furthermore, as illustrated in Fig. 1, in the hydrometallurgical plant 10, the preliminary neutralization facility 12 is configured such that the neutralization treatment tanks $12A_{(n)}$ of the first stage are provided in a plurality (n) of lines so as to correspond to the respective lines of the leaching treatment tanks $11_{(n)}$ provided in the leaching facility 11, and the leach slurries pH-adjusted in the neutralization treatment tanks $12A_{(n)}$ of the first stage in the respective lines are merged in the neutralization treatment tank 12B of the second stage made up of a single line, and furthermore, leachate merged in the neutralization treatment tank of the second stage is transported to the solid-liquid separation facility.

[0087] According to the thus-configured hydrometallurgical plant 10, when leaching treatment facilities each of which has a size having an operational track record (for example, 10,000 tons/year to 20,000 tons/year of leachate production amount in terms of the amount of nickel) are used in a plurality lines, nickel oxide ore throughput can be increased. Furthermore, in the subsequent downstream steps, that is, in the steps downstream from the preliminary neutralization step, the lines are united into one line, and therefore, the number of parts in the whole of the plant can be reduced, whereby facility costs are reduced.

[0088] Furthermore, according to this hydrometallurgical plant 10, even in the case where variations in pH and the like of leach slurries obtained from the treatment facilities (the leaching treatment tanks $11_{(n)}$, the neutralization treatment tanks $12A_{(n)}$ of the first stage) in the plurality of lines arise, the variations can be eliminated because the leached slurries discharged from the respective lines are merged in the neutralization treatment tank 12B of the second stage, and consequently, a solid-liquid separation treatment can be applied to uniform leach slurry.

[0089] Furthermore, although details will be described, according to this hydrometallurgical plant 10, the pipings 21, 22, and 23 to connect the neutralization treatment tanks $12A_{(n)}$ of the first stage to reaction tanks of the treatment facilities in other steps are appropriately provided. Thus, for example, leach slurry in a state where, immediately after plant operation startup or the like, a leaching treatment does not sufficiently proceed yet can be prevented from being transported to the solid-liquid separation step S3 and steps downstream therefrom, and accordingly, the occurrence of a poor reaction and a decrease in operation efficiency in the each step can be effectively prevented.

<3-1-2. Operation flow of normal operation>

[0090] Here, an operation method for a normal operation of the foregoing hydrometallurgical plant 10 will be described. Fig. 3 illustrates an operation flow of a normal operation. It should be noted that, here, description will be made by giving an example in which, as illustrated in Fig. 1 and Fig. 3, here, treatment facilities made up of a plurality of lines are made up of two lines ($n = 2$), that is, "a first line (1)" and "a second line (2)".

[0091] As shown by solid-black arrows in Fig. 3, in this hydrometallurgical plant 10, for example, slurry of nickel oxide ore (ore slurry) which are ground to a predetermined size in an ore processing step or the like is fed into a leaching treatment tank $11_{(1)}$ in the first line and a leaching treatment tank $11_{(2)}$ in the second line which are provided in a leaching treatment facility 11, whereby a leaching treatment is applied to ore slurry in the leaching treatment tanks $11_{(1)}$ and $11_{(2)}$ in the respective lines.

[0092] Next, leach slurries obtained by the leach treatment in the leaching treatment tanks $11_{(1)}$ and $11_{(2)}$ are transported to the preliminary neutralization facility 12. Specifically, leached slurries discharged from the leaching treatment tanks $11_{(1)}$ and $11_{(2)}$ are fed into neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first stage which correspond to the respective lines of the leaching treatment tanks $11_{(1)}$ and $11_{(2)}$. Then, in the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ in the respective lines, a neutralizer is added to the fed leach slurries to adjust the pH of the slurries to a predetermined pH range.

[0093] Next, leach slurries pH-adjusted in the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first stage are transported to and fed into the neutralization treatment tank 12B of the second stage. That is, leach slurries which are pH-adjusted in the neutralization treatment tank $12A_{(1)}$ in the first line and neutralization treatment tank $12A_{(2)}$ in the second line, respectively, are merged in the neutralization treatment tank 12B of the second stage made up of a single line. Thus, the merging of leach slurries transported from the lines in the neutralization treatment tank 12B of the second stage enables variations in properties such as pH to be eliminated, whereby uniform leach slurry can be transported to downstream steps. It should be noted that, also in the neutralization treatment tank 12B of the second stage, a neutralizer may be added to the merged leach slurry to make fine adjustments of the pH of the leach slurry.

[0094] In the transport of leach slurry to the neutralization treatment tank 12B of the second stage, the leach slurry is made to overflow and transported via pipings $24_{(1)}$ and $24_{(2)}$ configured to connect the respective neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first step to the neutralization treatment tank 12B of the second stage.

[0095] Subsequently, leach slurry is discharged from the neutralization treatment tank 12B of the second stage, and the leach slurry is transported to the solid-liquid separation facility 13. For example, as illustrated in Fig. 3, the solid-liquid separation facility 13 is a facility in which thickeners in six stages (CCD1 to CCD6) are connected and which is configured to feed transported leach slurry into a thickener of a first of the six stages. The transport of leach slurry to

the solid-liquid separation facility 13 is performed via piping 25 configured to connect an outlet portion of the neutralization treatment tank 12B of the second stage to an inlet portion of the thickener (CCD1) of the first stage, by using a transport pump 32 provided in the piping 25.

[0096] After that, in the solid-liquid separation facility 13, in the process of the transport of fed leach slurry from CCD 1 to CCD6 in this order, the slurry comes into contact with a countercurrent of a washing liquid fed into CCD6 of the last stage and residues in the slurry aggregate. Then, finally, a leachate having a high concentration of valuable metals such as nickel (a crude nickel sulfate solution) is discharged from CCD1. On the other hand, a leach residue having a low concentration of valuable metals such as nickel is discharged from CCD6 of the final stage, and transported to the final neutralization facility 14 to be rendered harmless.

<3-2. Configuration for self-circulation and operation flow of self-circulation>

<3-2-1. Configuration for self-circulation>

[0097] At the time of startup (operation start, startup) of the hydrometallurgical plant 10 after an periodic inspection and after a shutdown of one or both of the two lines, a predetermined time is needed until a leaching treatment in the leaching facility 11 reaches a level of normal (regular) operation. Specifically, in the leaching facility 11, a leaching treatment is performed under high temperature and high pressure, and therefore, an increase in temperature to a predetermined temperature is needed. Therefore, in an early stage immediately after operation startup and the like, a treatment to leach out a valuable metal from ore slurry is scarcely started, and accordingly, from the leaching treatment tanks 11₍₁₎ and 11₍₂₎ which constitute the leaching facility 11, leach slurry in a state in which the leaching treatment has not been sufficiently completed yet is discharged.

[0098] In the case where such leach slurry is transported as it is to treatment facilities in which the preliminary neutralization step S2 and the solid-liquid separation step S3 are performed, an obtained leachate has a greatly low concentration of valuable metals, and a poor sulfurization reaction and a decrease in operation efficiency in the nickel recovery step S6 and the like are caused. Such low concentration of valuable metals is caused particularly by leach slurry discharged at an early stage immediately after start of the leaching treatment in the leaching treatment tanks 11₍₁₎ and 11₍₂₎ and waste water for temperature increase and the like, discharged from the leaching facility 11 when, under a status where one line is normally operated, other lines are started up.

[0099] Therefore, as illustrated in Fig. 4, in the hydrometallurgical plant 10 according to the present embodiment, installed are pipings 21₍₁₎ and 21₍₂₎ to connect neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage in the preliminary neutralization facility 12 to the leaching treatment tanks 11₍₁₎ and 11₍₂₎ in the leaching facility 11, respectively. The pipings 21₍₁₎ and 21₍₂₎ are to connect the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage and inlet portions of the leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively, in which the neutralization treatment tank 12A₍₁₎ and the leaching treatment tank 11₍₁₎, and the neutralization treatment tank 12A₍₂₎ and the leaching treatment tank 11₍₂₎ are in the same line, respectively. That is, for example, the piping 21₍₂₎ connects the leaching treatment tank 11₍₂₎ in the second line to the neutralization treatment tank 12A₍₂₎ in the second line.

[0100] The pipings 21₍₁₎ and 21₍₂₎ enable a process liquid for increasing a temperature of the leaching treatment tanks 11₍₁₎ and 11₍₂₎ (a liquid for temperature increase) and low-nickel-concentration leach slurries discharged from the leaching treatment tanks 11₍₁₎ and 11₍₂₎ to be circulated between the leaching treatment tanks 11₍₁₎ and 11₍₂₎ and the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎, respectively, at the time of the foregoing startup after start of operation. Thus, the pipings 21₍₁₎ and 11₍₂₎ are piping for self-circulation which is capable of self-circulation of leach slurries discharged from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage and process liquids to the leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively, in which the neutralization treatment tank 12A₍₁₎ and the leaching treatment tank 11₍₁₎, and the neutralization treatment tank 12A₍₂₎ and the leaching treatment tank 11₍₂₎ are in the same line, respectively.

[0101] As illustrated in Fig. 4, the pipings 21₍₁₎ and 21₍₂₎ may extend from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage, respectively, and then, be merged at a predetermined point (in Fig. 1 and Fig. 4, an installation point of the transport pump 31), branch out again, and be connected to the leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively, or completely independent piping may be installed in every line. Furthermore, the pipings 21₍₁₎ and 21₍₂₎ are provided with a transport pump 31, and leach slurries discharged from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ are transported to the leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively, by the transport pump 31.

[0102] Furthermore, for example, between the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ and the foregoing transport pump 31, ON/OFF valves 42₍₁₎ and 42₍₂₎ to control the transport of leach slurry are provided inside the pipings 11₍₁₎ and 21₍₂₎, respectively. Then, although details will be described later, when leach slurry is made to self-circulate between the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage and the leaching treatment tanks 11₍₁₎ and 11₍₂₎, the ON/OFF valves 42₍₁₎ and 42₍₂₎ are brought into an ON state ("open" state) to make possible the transport of discharged leach slurry. It should be noted that, at the time of the foregoing normal operation, the ON/OFF valves 42₍₁₎ and 42₍₂₎ provided in the respective pipings for self-circulation 21₍₁₎ and 21₍₂₎ are in an OFF state ("closed" state).

<3-2-2. Operation flow of self-circulation>

[0103] Next, an operation method in the self-circulation using the foregoing pipings for self-circulation 21₍₁₎ and 21₍₂₎ in the hydrometallurgical plant 10 will be described using an operation flow of the self-circulation illustrated in Fig. 4. It should be noted that, as illustrated in Fig. 4, description will be made by taking, as an example, a case where self-circulation operation is performed in treatment facilities in the second line out of a plurality of lines, that is, the first line and the second line. Hereinafter, likewise, an operation performed after startup of treatment facilities on the second line will be taken as an example and described.

[0104] For example, at a stage where treatment facilities only in the second line are started up, that is, at an early stage immediately after operation startup or the like, even if a leaching treatment is applied to ore slurry in the leaching treatment tank 11₍₂₎ of the leaching facility 11, for example, temperature increase in the leaching treatment tank 11₍₂₎ is insufficient, whereby obtained leach slurry is in an insufficient leached state. Furthermore, immediately after the operation startup, a process liquid (a liquid for temperature increase) such as warm water is fed to perform a temperature increase treatment in order to increase the temperature of the leaching treatment facility 11₍₂₎.

[0105] Then, at such stage, as shown by flows indicated by hollow arrows in Fig. 4, leach slurry or a process liquid is discharged from the leaching treatment tank 11₍₂₎ and transported to the neutralization treatment tank 12A₍₂₎ of the first stage in the same line. After that, the leach slurry or the process liquid is self-circulated between the neutralization treatment tank 12A₍₂₎ of the first stage and the leaching treatment tank 11₍₂₎ via the piping 21₍₂₎ to connect the neutralization treatment tank 12A₍₂₎ and the leaching treatment tank 11₍₂₎.

[0106] Specifically, in the self-circulation of leach slurry or a process liquid, the ON/OFF valve 42₍₂₎ provided in the piping for self-circulation 21₍₂₎ to connect the neutralization treatment tank 12A₍₂₎ of the first stage to the leaching treatment tank 11₍₂₎ is brought into an ON state ("open" state). Then, the leach slurry or the process liquid is circulated from the neutralization treatment tank 12A₍₂₎ to the leaching treatment tank 11₍₂₎ by the transport pump 31 provided in the piping for self-circulation 21₍₂₎.

[0107] This self-circulation operation is performed until, for example, the temperature of the leaching treatment tank 11₍₂₎ is sufficiently increased. It should be noted that, at the time of this self-circulation, the supply of ore slurry and the supply of sulfuric acid to the leaching treatment tank 11₍₂₎ are suspended. Therefore, when leach slurry is circulated, the leach slurry has a valuable metal concentration of substantially approximately 0 g/L in terms of the amount of nickel.

[0108] As mentioned above, in the hydrometallurgical plant 10 according to the present embodiment, the provision of the pipings 21₍₁₎ and 21₍₂₎ to connect the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage to the leaching treatment tanks 11₍₁₎ and 11₍₂₎, respectively, makes possible the self-circulation of leach slurry or a process liquid for temperature increase at an early stage immediately after operation startup or the like. This can prevent leach slurry containing little nickel and a process liquid from being transported to downstream steps such as the solid-liquid separation step S3.

<3-3. Configuration for transport to final neutralization facility, and operation flow of transport to final neutralization facility>

<3-3-1. Configuration for transport to final neutralization facility>

[0109] Furthermore, even in a state where, in a startup operation after operation start, for example, temperature increase in the leaching treatment tank 11₍₂₎ is completed and the supply of ore slurry and sulfuric acid is started, leaching treatment is not sufficiently carried out yet in the leaching treatment tank 11₍₂₎, and accordingly, leach slurry having a desired nickel concentration is not discharged. Such leach slurry immediately after start of leaching in which little nickel and the like are leached out cannot still be transported to the subsequent step.

[0110] Therefore, as illustrated in Fig. 5, in the hydrometallurgical plant 10 according to the present embodiment, installed is the piping 22 to connect the neutralization treatment tanks 12₍₁₎ and 12A₍₂₎ of the first stage in the preliminary neutralization facility 12A to the leaching treatment tanks 11₍₁₎ and 11₍₂₎ in the leaching facility 11 and the final neutralization facility 14. This piping 22 is led individually from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage in the respective lines and connected to an inlet portion of the final neutralization facility 14, or the piping 22 led from the respective lines is united at a predetermined point and connected to the inlet portion of the final neutralization facility 14.

[0111] The piping 22 is provided with a transport pump 31, and configured to transport leach slurries discharged from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage to the final neutralization facility 14 by the transport pump 31.

[0112] Furthermore, for example, between the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ and the foregoing transport pump, the ON/OFF valves 42₍₁₎ and 42₍₂₎ to control transport of leach slurry are provided inside the piping 22. Then, although details will be described later, when leach slurry is transported from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage to the final neutralization facility 14, the ON/OFF valves 42₍₁₎ and 42₍₂₎ are brought

into an ON state ("open" state) to make possible the transport of the discharged leach slurry. It should be noted that, at the time of the foregoing normal operation, the ON/OFF valves 42₍₁₎ and 42₍₂₎ provided in the piping for transport to the final neutralization facility 14 is in an OFF state ("closed" state).

<3-3-2. Operation flow of transport to final neutralization facility>

[0113] Next, an operation method in the transport to the final neutralization facility 14 by using the foregoing piping 22 in the hydrometallurgical plant 10 will be described using an operation flow of Fig. 5. It should be noted that, as illustrated in Fig. 5, description will be given by taking, as an example, a case where an operation to transport leach slurry to the final neutralization facility 14 in treatment facilities in the second line out of a plurality of lines, that is, the first line and the second line.

[0114] For example, at a stage where a startup operation is performed for the treatment facilities only in the second line and then temperature increase in the leaching treatment tank 11₍₂₎ is completed, a leaching treatment has proceeded in the leaching treatment tank 11₍₂₎ little by little, but not been sufficiently completed yet, and therefore, discharged leach slurry has a low nickel concentration.

[0115] Then, at such stage, as shown by flows indicated by hollow arrows in Fig. 5, first, leach slurry is discharged from the leaching treatment tank 11₍₂₎ and transported to the neutralization treatment tank 12A₍₂₎ of the first stage in the same line. After that, leach slurry is transported from the neutralization treatment tank 12A₍₂₎ to the final neutralization facility 14 via the piping 22 to connect the neutralization treatment tank 12A₍₂₎ to the final neutralization facility 14.

[0116] Specifically, in the transport of leach slurry to the final neutralization facility 14, an ON/OFF valve 43 provided in the foregoing piping for self-circulation 21₍₂₎ (piping to connect the neutralization treatment tank 12A₍₂₎ of the first stage and the leaching treatment tank 11₍₂₎) is brought into an OFF state ("closed" state). Next, the ON/OFF valve 42₍₂₎ provided in the piping 22 to connect the neutralization treatment tank 12A₍₂₎ of the first stage and the final neutralization facility 14 is brought into an ON state ("open" state). Then, leach slurry is transported from the neutralization treatment tank 12A₍₂₎ to the final neutralization facility 14 by the transport pump 31 provided in the piping 22.

[0117] This transport operation of leach slurry to the final neutralization facility 14 is performed, for example, when the nickel concentration of leach slurry discharged from the leaching treatment tank 11₍₂₎ is lower than the nickel concentration of a liquid phase in a thickener of the last stage (CCD6) out of thickeners provided in multiple stages in the solid-liquid separation facility 13. It should be noted that, at this stage, that is, at a stage of the transport operation to the final neutralization facility 14, leach slurry has a valuable metal concentration of, for example, approximately 0 to 5 g/L in terms of the amount of nickel.

[0118] As mentioned above, in the hydrometallurgical plant 10 according to the present embodiment, the provision of the piping 22 to connect the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage to the final neutralization facility 14 makes it possible that leach slurry discharged at a stage where a leaching treatment has not sufficiently proceed yet after operation start is transported to the final neutralization facility 14. This can prevent leach slurry having a low nickel concentration from being transported to downstream steps such as the solid-liquid separation step S3.

<3-4. Configuration for transport to solid-liquid separation tank, and operation flow of transport to solid-liquid separation tank>

<3-4-1. Configuration for transport to solid-liquid separation tank>

[0119] Furthermore, even in the case where a leaching treatment gradually proceeds after operation startup and the nickel concentration of leach slurry discharged from the leaching treatment tank 11₍₂₎ becomes higher than the nickel concentration of a leachate in the thickener of the last stage (CCD6) in the solid-liquid separation facility, unless the nickel concentration of the leach slurry is sufficiently high, the leach slurry cannot be transported to a subsequent step. That is, in the case where the nickel concentration of the leach slurry is lower than a desired nickel concentration of leach slurry to be transported to the neutralization treatment tank 12B of the second stage, the leach slurry cannot be transported to a subsequent step.

[0120] Therefore, as illustrated in Fig. 6, in the hydrometallurgical plant 10 according to the present embodiment, installed is the piping 23 to connect the neutralization treatment tanks 12₍₁₎ and 12A₍₂₎ of the first stage in the preliminary neutralization facility 12 to the solid-liquid separation tanks (thickeners) provided in multiple stages in the solid-liquid separation facility 13. This piping 23 is led individually from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage in the respective lines and connected to inlet portions of the solid-liquid separation tanks, or the piping 23 led from the respective lines is united at a predetermined point and connected to the inlet portions of the solid-liquid separation tanks. More specifically, this piping 23 extends from the neutralization treatment tanks 12A₍₁₎ and 12A₍₂₎ of the first stage in the direction of the solid-liquid separation facility 13, and branches out so as to be coupled to each of the solid-liquid separation tanks (CCD1, CCD2, ... and CCD6) which are connected in multiple stages and constitute the solid-liquid

separation facility 13.

[0121] This piping 23 is provided with a transport pump 31 and is configured to transport leach slurry discharged from the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first stage to a predetermined solid-liquid separation tank in the solid-liquid separation facility 13 by the transport pump 31.

[0122] Furthermore, for example, between the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ and the foregoing transport pump 31, the ON/OFF valves $42_{(1)}$ and $42_{(2)}$ to control the transport of leach slurry are provided inside the piping 23. Then, although details will be described later, when leach slurry is transported from the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ to a predetermined solid-liquid separation tank in the solid-liquid separation facility 13, the ON/OFF valves $42_{(1)}$ and $42_{(2)}$ are brought into an ON state ("open" state) to make possible the transport of discharged leach slurry. It should be noted that, at the time of the foregoing normal operation, the ON/OFF valves $42_{(1)}$ and $42_{(2)}$ provided in the piping 23 for the transport to a predetermined solid-liquid separation tank is in an OFF state ("closed" state).

[0123] Furthermore, this piping 23 is provided with an ON/OFF valve 44 to control the transport of leach slurry at each of junctions toward the respective multistage-connected solid-liquid separation tanks. This provision makes it possible to control the transport of leach slurry to a solid-liquid separation tank which is an appropriate transport destination in accordance with the nickel concentration of the leach slurry to be transported. A method for the control of a transport destination may be such that a switchover valve to perform switchover among transfer destinations is provided at a predetermined junction, whereby switchover control is carried out by the switchover valve.

<3-4-2. Operation flow of transport to solid-liquid separation tank>

[0124] Next, an operation method in the transport to solid-liquid separation tanks constituting the solid-liquid separation facility 13 by using the foregoing piping 23 in the hydrometallurgical plant 10 will be described using an operation flow of Fig. 6. It should be noted that, as illustrated in Fig. 6, description will be given by taking, as an example, a case where an operation to transport leach slurry to a solid-liquid separation tank of a second stage (CCD2) in the solid-liquid separation facility 13 in treatment facilities in the second line out of a plurality of lines, that is, the first line and the second line.

[0125] For example, even if there is a state where a startup operation of treatment facilities in the second line is performed and then a leaching treatment gradually proceeds, unless the leaching treatment sufficiently proceeds to a normal operation level, the nickel concentration of leach slurry discharged from the leaching treatment tank $11_{(2)}$ is low, and therefore, the leach slurry is not allowed to be transported to a subsequent step. Specifically, for example, even in the case where a leaching treatment proceeds and the valuable metal concentration of leach slurry is more than 5 g/L in terms of the amount of nickel, when the nickel concentration of the leach slurry is lower than a desired nickel concentration of leach slurry to be transported to the neutralization treatment tank 12B of the second stage, the leach slurry is not allowed to be transported to a subsequent step.

[0126] Then, in such case, as shown by flows indicated by hollow arrows in Fig. 6, first, leach slurry is discharged from the leaching treatment tank $11_{(2)}$ and transported to the neutralization treatment tank $12A_{(2)}$ of the first stage in the same line. After that, leach slurry is transported from the neutralization treatment tank $12A_{(2)}$ to the solid-liquid separation facility 13 via the piping 23 to connect the neutralization treatment tank $12A_{(2)}$ to the solid-liquid separation facility 13.

[0127] At this time, in accordance with the valuable metal concentration of leach slurry, the leach slurry is transported to a solid-liquid separation tank corresponding to the valuable metal concentration. For example, in the case where the valuable metal concentration of leach slurry is 2.5 g/L in terms of the amount of nickel, the leach slurry is transported to the solid-liquid separation tank of the second stage (CCD2) in which a liquid phase has a concentration of approximately 2.5 g/L in terms of the amount of nickel at the time of normal (regular) operation. A transport destination is thus appropriately controlled in accordance with the valuable metal concentration of leach slurry, whereby the first line under the normal operation can be prevented from being affected, and an efficient operation becomes feasible.

[0128] Specifically, in the transport of leach slurry to CCD2 in the solid-liquid separation facility 13, the ON/OFF valve 43 provided in the foregoing piping for self-circulation $21_{(2)}$ (piping to connect the neutralization treatment tank $12A_{(2)}$ of the first stage to the leaching treatment tank $11_{(2)}$) is brought into an OFF state ("closed" state). Furthermore, an ON/OFF valve 45 provided in the foregoing piping 22 to transport leach slurry to the final neutralization facility 14 (piping to connect the neutralization treatment tank $12A_{(2)}$ of the first stage to the final neutralization facility 14) is brought into an OFF state ("closed" state).

[0129] Next, the ON/OFF valve $42_{(2)}$ provided in the piping 23 to connect the neutralization treatment tank $12A_{(2)}$ of the first stage to the solid-liquid separation facility 13 is brought into an ON state ("open" state). Then, leach slurry is transported from the neutralization treatment tank $12A_{(2)}$ of the first stage to the solid-liquid separation facility 13 by a transport pump 31 provided in the piping 23.

[0130] At this time, ON/OFF valves 44 provided at junctions for branching toward respective solid-liquid separation tanks in the solid-liquid separation facility 13 are controlled to transport the leach slurry to CCD2. Specifically, an ON/OFF valve 44 at a junction toward CCD2 is brought into an ON state ("open" state), on the other hand, other ON/OFF valves

44 at respective junctions toward from CCD1, CCD3 to CCD6 are brought into an OFF state ("closed" state).

[0131] As mentioned above, in the hydrometallurgical plant 10 according to the present embodiment, the provision of the piping 23 to connect the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first stage to the solid-liquid separation facility 13 makes it possible that leach slurry having not sufficiently undergone a leach treatment yet after start of operation and having a low nickel concentration is transported to a predetermined solid-liquid separation tank. This can prevent low-nickel-concentration leach slurry from being transported with being mixed with leach slurry discharged from a line in which the normal operation continues, and prevent poor reactions and a decrease in operation efficiency in downstream steps.

<3-5. Shift from unusual operation to normal operation>

[0132] Then, when a predetermined amount of time has elapsed since start of operation and the valuable metal concentration of leach slurry discharged from the leaching treatment tank $11_{(2)}$ and operation conditions such as a flow rate for liquid transport return to the levels of the normal operation, the foregoing routes for an unusual operation are closed, and the normal operation is performed using a route for the normal operation.

[0133] That is, leach slurry discharged from the leaching treatment tank $11_{(2)}$ is transported to the neutralization treatment tank $12A_{(2)}$ of the first stage, and then, leach slurry is made to overflow into the neutralization treatment tank 12B of the second stage via the piping $24_{(2)}$ to connect the neutralization treatment tank $12A_{(2)}$ of the first stage to the neutralization treatment tank 12B of the second stage. Then, leach slurry is transported from the neutralization treatment tank 12B of the second stage to CCD1 in the solid-liquid separation facility 13 to undergo a solid-liquid separation treatment.

<3-6. Conclusion>

[0134] As mentioned above, the hydrometallurgical plant 10 according to the present embodiment makes it possible that, while facility costs are reduced, nickel oxide ore throughput is increased, whereby the production amount of a nickel-cobalt mixed sulfide is improved. Furthermore, even in the case where variations in the properties, such as pH, of leach slurries obtained from treatment facilities in a plurality of lines arise, the leach slurries discharged from the respective lines are merged in the neutralization treatment tank 12B of the second stage, and therefore, the variations can be eliminated, whereby a solid-liquid separation treatment can be applied to uniform leach slurry.

[0135] Furthermore, since this hydrometallurgical plant 10 is provided with the foregoing pipings 21, 22, and 23, leach slurry having a low nickel concentration can be prevented from being transported to downstream steps at an unusual time such as startup of treatment facilities. This can prevent a poor reaction and a decrease in operation efficiency in downstream steps.

[0136] Furthermore, in the hydrometallurgical plant 10, the foregoing pipings 21, 22, and 23 are connected from the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of the first stage in the preliminary neutralization facility 12 made up of neutralization treatment tanks in two stages. Thus, an operation in one line where the normal operation continues to be performed is not affected. That is, as illustrated in the examples of Figs. 4 to 6, it is made possible that, in the second line under a startup operation, leach slurry is self-circulated, or transported to the final neutralization facility 14 and the solid-liquid separation facility 13, while, in the first line, the normal operation is performed as shown by flows indicated by a solid-black arrows.

[0137] As mentioned above, in the hydrometallurgical plant 10, neutralization treatment tanks are provided in two stages and only neutralization treatment tanks of a first of the two stages are provided in a plurality of lines, whereby a startup operation at the time of start of operation (unusual operation) can be performed without affecting the one of the two lines.

[0138] It should be noted that, in the case where the unusual operation is performed in one of the lines (for example, the second line), compared with a case where the normal operation is performed in both of the lines, the liquid amount of leach slurry transported to the neutralization treatment tank 12B of the second stage is smaller. Therefore, the performance of a pump for the normal operation and throughput in downstream steps are reduced to a level corresponding to the foregoing liquid amount, and the operation continues to be performed. However, as mentioned above, in another of the lines (for example, the first line), the normal operation can be performed without stopping the operation, and therefore, the quality and the like of a product is not affected at all.

[0139] Fig. 1 and Figs. 3 to 6 illustrate a configuration in which pipings 21, 22, and 23 used for the unusual operation are partly shared. Furthermore, the transport pump 31 to transport leach slurry through those pipings 21, 22, and 23 is also shared. However, the present invention is not limited to this, and, as a matter of course, the pipings 21, 22, and 23 may be completely individually provided, and each of the pipings 21, 22, and 23 may be provided with a transport pump. In this hydrometallurgical plant 10, it is beneficial that, in consideration of a transport route and the like, the arrangement of the piping is suitably determined. It should be noted that piping is preferably shared in a sharable portion of the piping

to make possible a reduction in the number of facilities and costs.

[0140] Furthermore, Fig. 1 and Figs. 3 to 6 illustrate an aspect in which all of the pipings 21, 22, and 23 used for the unusual operation are provided, but, an aspect in which any one or two of the pipings are provided may be adopted.

«4. Examples »

[0141] Next, Examples adopting the present invention will be described, but the present invention is not limited to the following Examples.

<Examples>

<Operation of hydrometallurgical plant>

<Operation Example 1>

[0142] In a hydrometallurgical plant for nickel oxide ores, treatment facilities were configured as illustrated in Fig. 1, and a 30-day hydrometallurgical operation was carried out.

[0143] That is, an operation was performed by the hydrometallurgical plant 10 including: the leaching treatment facility 11 having the leaching treatment tanks $11_{(1)}$ and $11_{(2)}$ in two lines; and the preliminary neutralization facility 12 provided with neutralization treatment tanks in two stages, in which the neutralization treatment tanks $12A_{(1)}$ and $12A_{(2)}$ of a first of the two stages were provided in the two lines so as to correspond to the respective leaching treatment tanks, and the neutralization treatment tank 12B of a second of the two stages was provided in a single line. It should be noted that, in the solid-liquid separation facility 13, as illustrated in Fig. 1, thickeners (CCD1 to CCD6) were connected in six stages to perform multistage washing.

[0144] As a result, during the period of 30 days, poor leaching and the like in the leaching facility in which high pressure acid leach was performed were not caused, and the operation did not stop in both of the two lines. Furthermore, the production amount of a nickel-cobalt mixed sulfide obtained by this operation was 2500 tons in terms of the amount of nickel, and there was no problem with the quality of the product.

[0145] It should be noted that set values of the valuable metal concentrations in liquid phases of CCDs of the stages in the solid-liquid separation facility 13 were not more than 3 g/L for CCD1, not more than 2.5 g/L for CCD2, not more than 2 g/L for CCD3, not more than 1.5 g/L for CCD4, not more than 1 g/L for CCD5, and not more than 0.5 g/L for CCD6, in terms of the amount of nickel.

<Operation Example 2>

[0146] Using the same plant as the hydrometallurgical plant 10 used in Operation Example 1, a 30-day hydrometallurgical operation was carried out. It should be noted that set values of the valuable metal concentrations in liquid phases of CCDs of the stages in the solid-liquid separation facility 13 were the same as those in Operation Example 1.

[0147] In the operation of Operation Example 2, during the period of the operation, shutdowns occurred five times due to facility troubles in the leaching treatment tank $11_{(1)}$ in the first line or the leaching treatment tank $11_{(2)}$ in the second line. Accordingly, the shutdown and startup operations of a line in which the facility troubles arose were performed five times. At this time, in the startup operation, as illustrated in Fig. 4 to Fig. 6, the unusual operation was performed in accordance with the nickel concentration of leach slurry discharged from the leaching treatment tank $11_{(1)}$ or $11_{(2)}$. It should be noted that, in such startup operation, an average time required from a shutdown to a return to normal was one day.

[0148] As a result of the 30-day operation, the production amount of a nickel-cobalt mixed sulfide obtained by this operation was 2075 tons (approximately 83% of that in Operation Example 1), and there was no problem with the quality of the product.

<Operation Example 3>

[0149] Using the same plant as the hydrometallurgical plant 10 used in Operation Example 1, a 30-day hydrometallurgical operation was carried out. It should be noted that set values of the valuable metal concentrations in liquid phases of CCDs of the stages in the solid-liquid separation facility 13 were the same as those in Operation Example 1.

[0150] Also in Operation Example 3, as is the case with Operation Example 2, during the period of the operation, poor leaching occurred five times in the leaching treatment tank $11_{(1)}$ in the first line or the leaching treatment tank $11_{(2)}$ in the second line. Accordingly, the shutdown and startup operations of a line in which the poor leaching occurred were performed five times. At this time, in Operation Example 3, the whole of the hydrometallurgical plant 10 was shut down.

It should be noted that, in such startup operation, an average time required from a shutdown to a return to normal was two days.

[0151] As a result of the 30-day operation, an obtained nickel-cobalt mixed sulfide had no problem in product quality, but the production amount thereof was very small, namely 1300 tons (approximately 52% of that in Operation Example 1), and thus a sufficient amount of a nickel-cobalt mixed sulfide cannot be produced.

[0152] The reason why, although a production amount equal to approximately 67% of that in Operation Example 1 was expected with theoretical simple calculation, an actual production amount was 1300 tons was considered that the whole of the hydrometallurgical plant 10 was shut down when poor leaching occurred. That is, it is considered that, since the whole of the plant was shut down, the need to perform the shutdown and re-startup of operation in the dezincification step S5, the nickel recovery step S6, or the like arose, and furthermore, operation startups of the treatment facilities in the plant were timed to each other, and therefore, excessive shutdown time was needed.

<Operation Example 4>

[0153] Using the same plant as the hydrometallurgical plant 10 used in Operation Example 1, a 30-day hydrometallurgical operation was carried out.

[0154] Also in Operation Example 4, as is the case with Operation Example 2, during the period of the operation, poor leaching occurred five times in the leaching treatment tank 11₍₁₎ in the first line or the leaching treatment tank 11₍₂₎ in the second line. Accordingly, the shutdown and startup operations of a line in which the poor leaching occurred were performed five times. At this time, in Operation Example 4, leach slurry discharged from the leaching treatment tank 11₍₁₎ or 11₍₂₎ under the startup operation, that is, leach slurry having not sufficiently undergone a leach treatment yet and accordingly having a low nickel concentration was transported as it was to the neutralization treatment tank 12B of the second stage via the neutralization treatment tank 12A₍₁₎ or 12A₍₂₎ of the first stage. It should be noted that, in such startup operation, an average time required from a shutdown to a return to normal was two days.

[0155] As a result of the 30-day operation, the production amount of an obtained nickel-cobalt mixed sulfide was 2250 tons (approximately 90% of that in Operation Example 1), but, the quality of the product was worse. Specifically, the percentage of valuable metals in the nickel-cobalt mixed sulfide decreased and varied, and thus, the nickel-cobalt mixed sulfide was a defective item which is not allowed to be delivered as a product, and accordingly had to be disposed of.

[0156] The reason for this is considered that, also in the startup operation (unusual operation), leach slurry obtained in a stage where leach treatment was not sufficiently completed yet was transported to downstream steps as it was. That is, it is considered that leach slurry having a low nickel concentration was transported to downstream steps, and solid-liquid separated, and sulfurization treatment was applied to an obtained leachate having a low nickel concentration in the nickel recovery step S6, and therefore, a poor sulfurization reaction was caused, and as a result, the quality of the product was worse.

[0157] It should be noted that, although set values of the valuable metal concentrations in liquid phases of CCDs of the stages in the solid-liquid separation facility 13 were the same as those in Operation Example 1, leach slurry having a low concentration was frequently accepted, and therefore, concentrations in the solid-liquid separation tanks (CCD) varied more widely, thereby preventing stable operations from being performed.

<Variations in nickel concentration of overflow liquid>

[0158] Next, in a case where the leaching treatment tank 11₍₁₎ or 11₍₂₎ in one line (the first line or the second line) in the leaching step S1 stopped due to a facility trouble, and then a startup operation was performed, variations in the nickel concentration of an overflow liquid in a solid-liquid separation tank (CCD1) of the first stage in each of the following Operation Example 5 and Operation Example 6 were examined.

<Operation Example 5>

[0159] In Operation Example 5, as is the case with the foregoing Operation Example 2, only in a shutdown line, circulation to a leaching treatment tank was performed at the time of temperature increase, and then, acid leaching was started, an operation for liquid transport to the final neutralization facility 14 (in the final neutralization step S7) or a solid-liquid separation tank having a suitable nickel concentration was performed in accordance with the nickel concentration until the nickel concentration reached a predetermined concentration (refer to Fig. 4 to Fig. 6).

[0160] The following table 1 shows variations in the nickel concentration (g/L) of an overflow liquid from the solid-liquid separation tank (CCD1) of the first stage in the case of performing the foregoing operation. As shown in Table 1, it is found that, in this Operation Example 5, the nickel concentration was maintained very stably at the same level since operation startup. Furthermore, in a sulfurization reaction in the sulfurization step as a downstream step of treating this overflow liquid, the reaction stably proceeded without causing a poor reaction and the like.

<Operation Example 6>

[0161] In Operation Example 6, as is the case with the foregoing Operation Example 4, all of a liquid at the time of temperature increase in a shutdown line and a leachate having a nickel concentration not reaching a predetermined concentration yet immediately after start of acid leaching were transported to the preliminary neutralization tank 12B of the second stage in the same manner as in a line in which the normal operation continued.

[0162] The following table 1 shows variations in the nickel concentration (g/L) of an overflow liquid from the solid-liquid separation tank (CCD1) of the first stage in the case of performing the foregoing operation. As shown in Table 1, it is understood that the nickel concentration sharply decreased from operation startup for half a day. Thus, such sharp decrease in the nickel concentration made it very difficult to control the sulfurization reaction in a sulfurization step as a downstream step, whereby a poor sulfurization reaction and an excessive sulfurization reaction were caused.

[Table 1]

	Nickel concentration of overflow liquid (g/L)	
	Operation Example 5	Operation Example 6
Start	3.2	3.0
2 hours later	3.1	3.3
4 hours later	3.3	2.8
6 hours later	3.3	2.4
8 hours later	3.2	2.1
10 hours later	3.0	2.5
12 hours later	3.2	2.8
14 hours later	3.1	2.9
16 hours later	3.3	3.1
18 hours later	3.2	3.2

Claims

1. A hydrometallurgical plant for nickel oxide ores, comprising at least:

a leaching facility provided with leaching treatment tanks in a plurality of lines to apply a leaching treatment to a nickel oxide ore;

a preliminary neutralization facility provided with neutralization treatment tanks in two stages to perform preliminary neutralization by which pH of leach slurry discharged from the leaching treatment tanks is adjusted to a predetermined range; and

a solid-liquid separation facility made up of a single line to perform solid-liquid separation of leach slurry pH-adjusted and discharged from the preliminary neutralization facility into a leachate and a leach residue in a solid-liquid separation tank,

wherein the preliminary neutralization facility is configured such that neutralization treatment tanks of a first of the two stages are provided in a plurality of lines so as to correspond to the respective lines of the leaching treatment tanks provided in the leaching facility, and leach slurries which are pH-adjusted in the neutralization treatment tanks of the first stage in the respective lines are merged in a neutralization treatment tank of a second of the two stages which is made up of a single line, and leach slurry merged in the neutralization treatment tank of the second stage is transported to the solid-liquid separation facility.

2. The hydrometallurgical plant for nickel oxide ores according to claim 1, wherein piping to connect each of the neutralization treatment tanks of the first stage to an inlet portion of a corresponding one, arranged in the same line, of the leaching treatment tanks in the leaching facility, is provided and wherein leach slurry or a process liquid discharged from each of the neutralization treatment tanks of the first stage is enabled to be circulated to a corresponding one, arranged in the same line, of the leaching treatment tanks in the leaching facility.

3. The hydrometallurgical plant for nickel oxide ores according to claim 1, further comprising:

a final neutralization facility to apply a neutralization treatment to a leach residue obtained by solid-liquid separation in the solid-liquid separation facility; and
 piping to connect the neutralization treatment tanks of the first stage to an inlet portion of the final neutralization facility, and
 wherein leach slurry discharged from the neutralization treatment tanks of the first stage is enabled to be transported to the final neutralization facility.

4. The hydrometallurgical plant for nickel oxide ores according to claim 1, wherein the solid-liquid separation facility is provided with solid-liquid separation tanks in multiple stages to perform solid-liquid separation of leach slurry discharged from the neutralization treatment tanks with multistage washing.

5. The hydrometallurgical plant for nickel oxide ores according to claim 4, wherein piping to connect the neutralization treatment tanks of the first stage to an inlet portion of each of the solid-liquid separation tanks provided in multiple stages in the solid-liquid separation facility is provided, and wherein leach slurry discharged from the neutralization treatment tanks of the first stage is enabled to be transported to the solid-liquid separation tanks.

6. The hydrometallurgical plant for nickel oxide ores according to claim 1, wherein a production amount of leach slurry in the leaching facility is from 10,000 tons/year to 20,000 tons/year in terms of nickel amount.

7. A method for operating a hydrometallurgical plant for nickel oxide ores to recover nickel and cobalt from a nickel oxide ore,

wherein the hydrometallurgical plant for nickel oxide ores comprises at least:

a leaching facility provided with leaching treatment tanks in a plurality of lines to apply a leaching treatment to a nickel oxide ore;
 a preliminary neutralization facility provided with neutralization treatment tanks in two stages to perform preliminary neutralization by which pH of leach slurry discharged from the leaching treatment tanks is adjusted to a predetermined range; and
 a solid-liquid separation facility made up of a single line to perform solid-liquid separation of leach slurry pH-adjusted and discharged from the preliminary neutralization facility into a leachate and a leach residue in a solid-liquid separation tank,

wherein, in the preliminary neutralization facility, neutralization treatment tanks of a first of the two stages are provided in a plurality of lines so as to correspond to the respective lines of the leaching treatment tanks provided in the leaching facility, and a neutralization treatment tank of a second of the two stages is made up of a single line, and wherein leach slurries discharged from the respective neutralization treatment tanks of the first stage are merged in the neutralization treatment tank of the second stage made up of a single line, and merged leach slurry is transported to the solid-liquid separation facility.

8. The method for operating a hydrometallurgical plant for nickel oxide ores according to claim 7, wherein piping to connect each of the neutralization treatment tanks of the first stage to an inlet portion of a corresponding one, arranged in the same line, of the leaching treatment tanks in the leaching facility is provided, and wherein, at a stage immediately after operation start, leach slurry or a process liquid discharged from the leaching treatment tanks is circulated from the neutralization treatment tanks of the first stage to the leaching treatment tanks via the piping.

9. The method for operating a hydrometallurgical plant for nickel oxide ores according to claim 7, wherein the solid-liquid separation facility is provided with solid-liquid separation tanks in multiple stages to perform solid-liquid separation of a leachate discharged from the neutralization treatment tanks with multistage washing.

10. The method for operating a hydrometallurgical plant for nickel oxide ores according to claim 9, wherein the hydrometallurgical plant further comprises: a final neutralization facility to apply a neutralization treatment to a leach residue obtained by solid-liquid separation in the solid-liquid separation facility; and piping to connect the neutralization treatment tanks of the first stage to an inlet portion of the final neutralization facility, and wherein, when a nickel concentration of leach slurry discharged from the leaching treatment tanks is lower than a

nickel concentration of a leachate in a solid-liquid separation tank of a last of the multiple stages in the solid-liquid separation facility, the leach slurry discharged from the leaching treatment tanks is transported from the neutralization treatment tank of the first stage to the final neutralization facility via the piping.

- 5 **11.** The method for operating a hydrometallurgical plant for nickel oxide ores according to claim 9,
 wherein piping to connect the neutralization treatment tanks of the first stage to an inlet portion of each of the solid-
 liquid separation tanks provided in multiple stages in the solid-liquid separation facility is provided, and
 wherein, when a nickel concentration of leach slurry discharged from the leaching treatment tanks is lower than a
 10 desired nickel concentration of a leachate to be transported to the neutralization treatment tank of the second stage,
 the leach slurry discharged from the leaching treatment tanks is transported from the neutralization treatment tanks
 of the first stage to a solid-liquid separation tank of a predetermined stage via the piping.

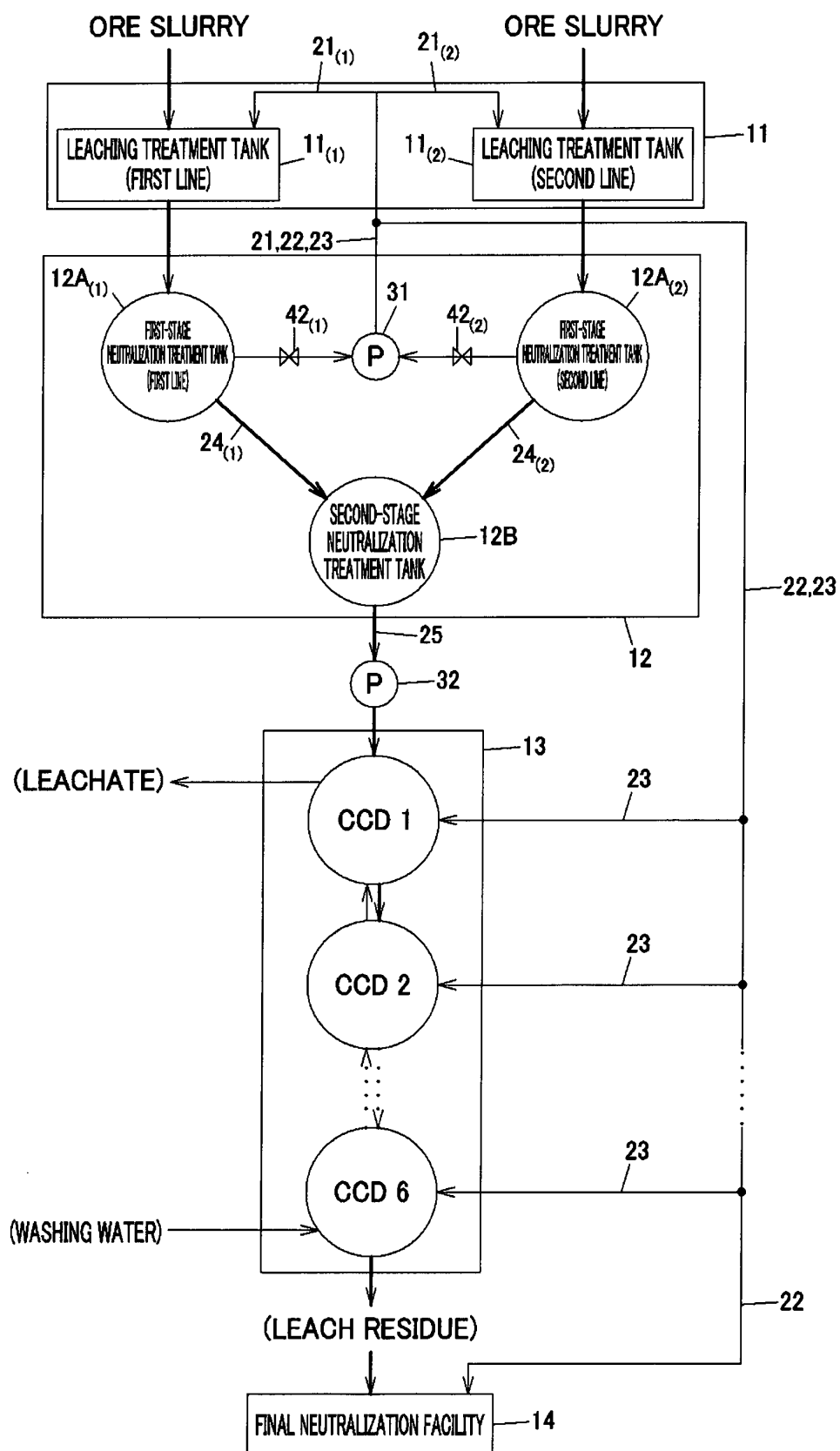


FIG.1

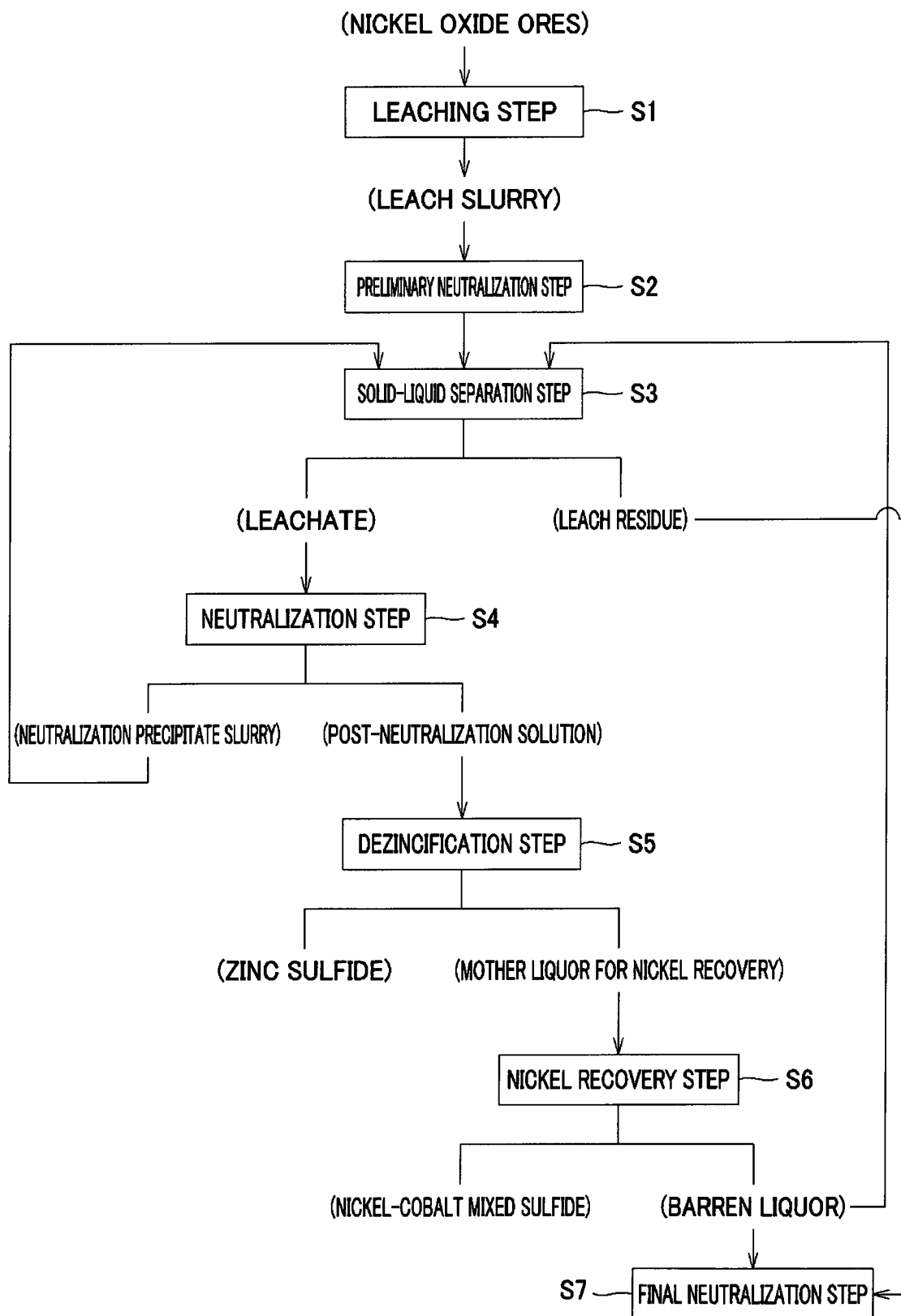


FIG.2

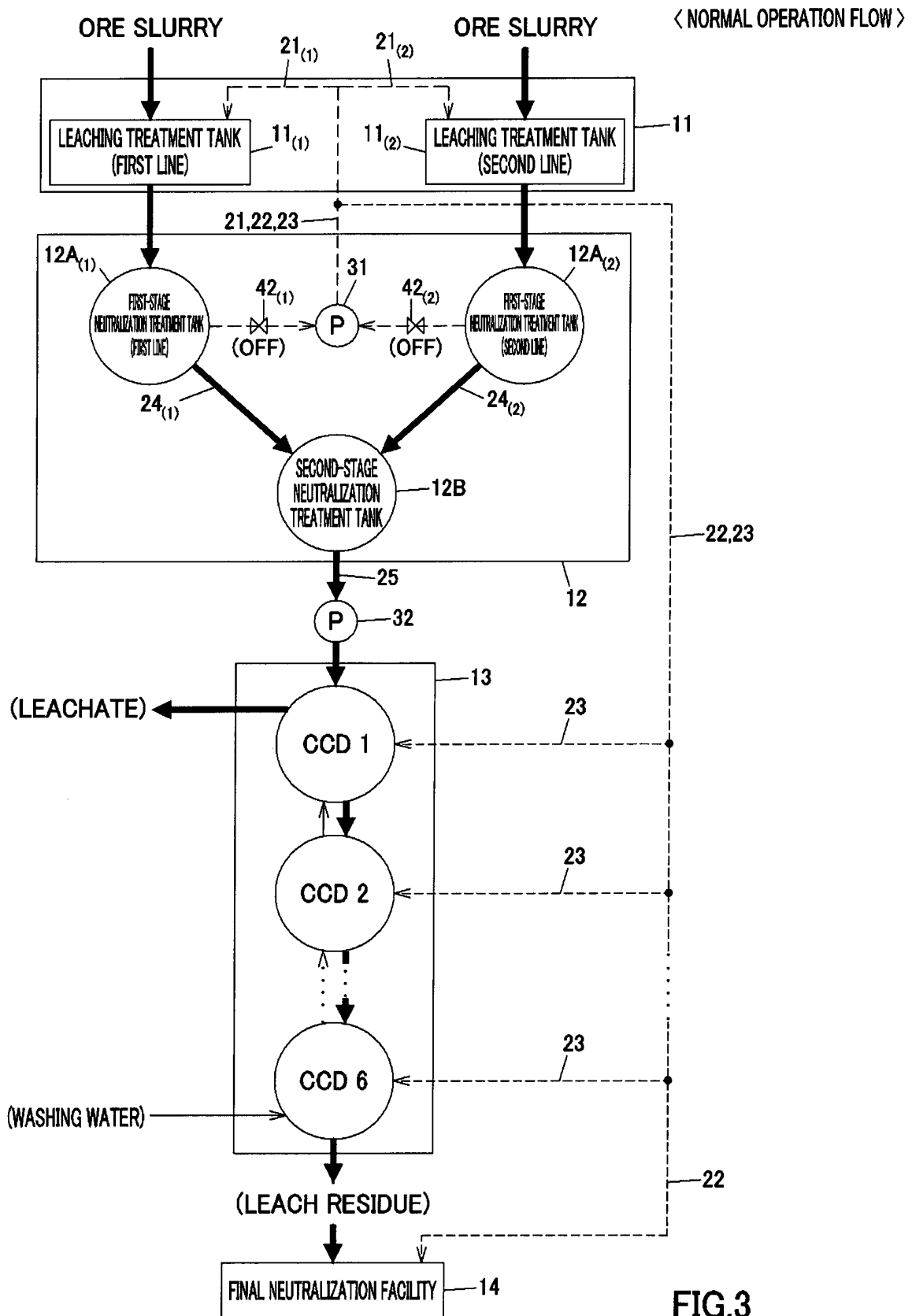


FIG.3

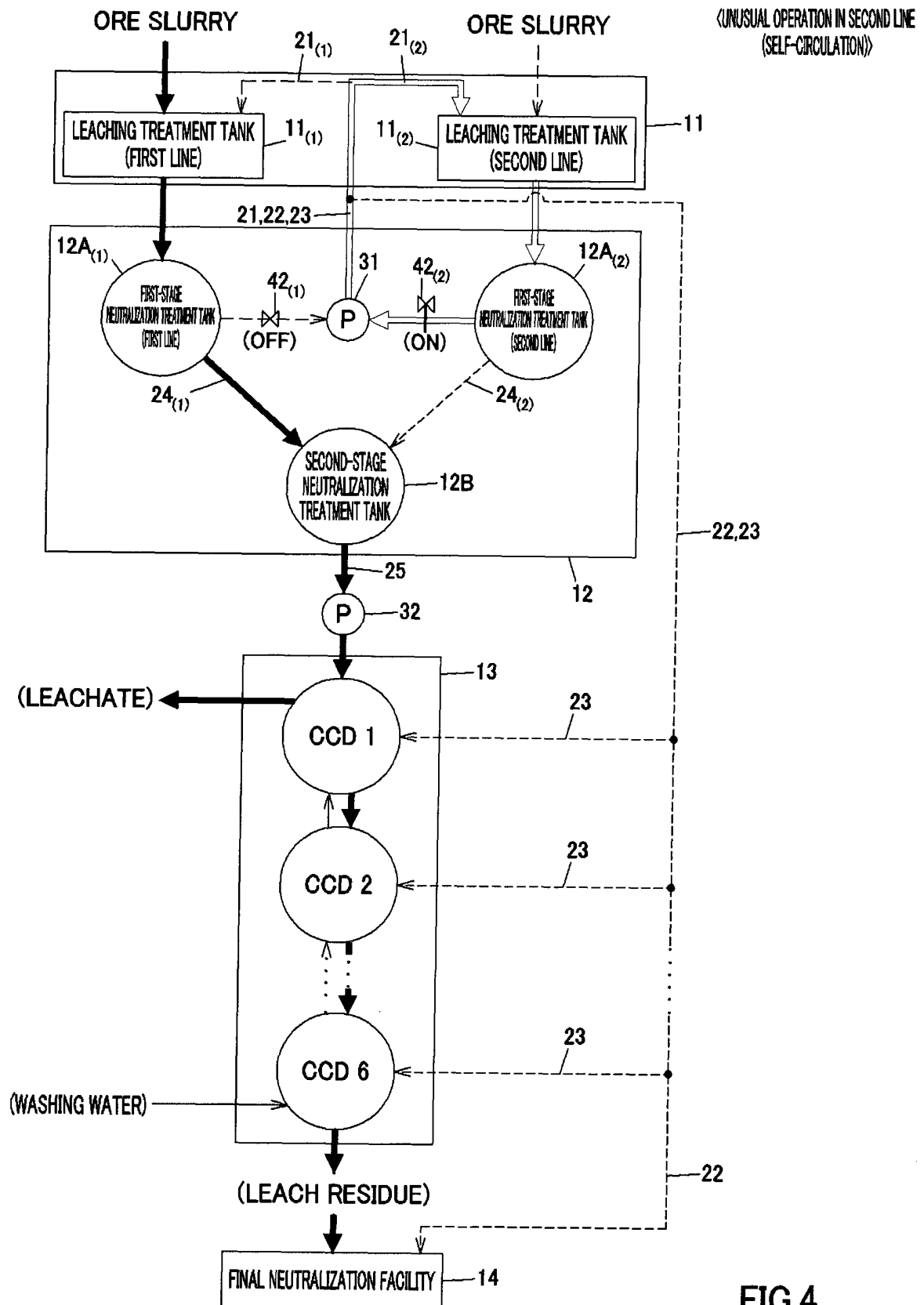
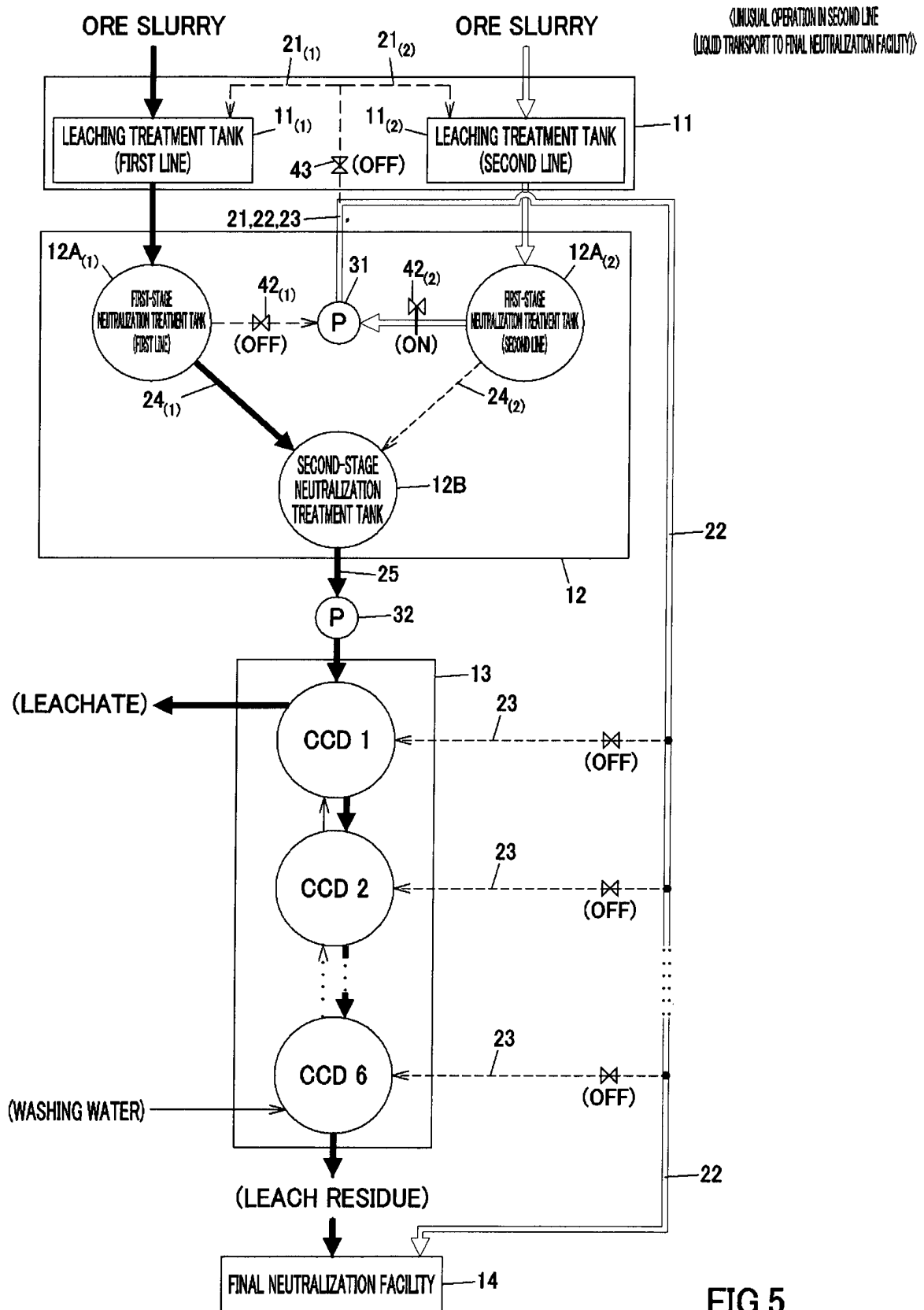
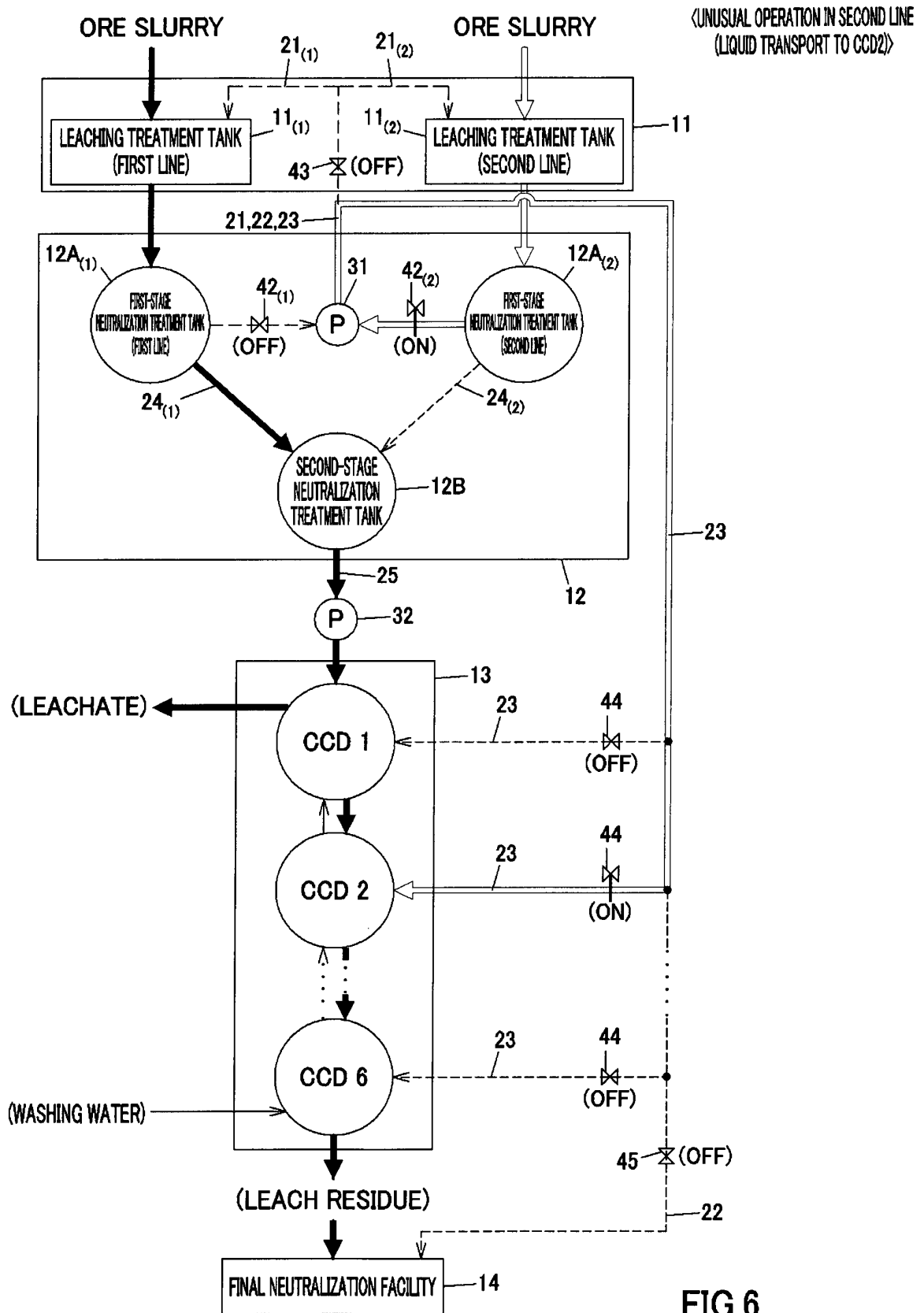


FIG.4





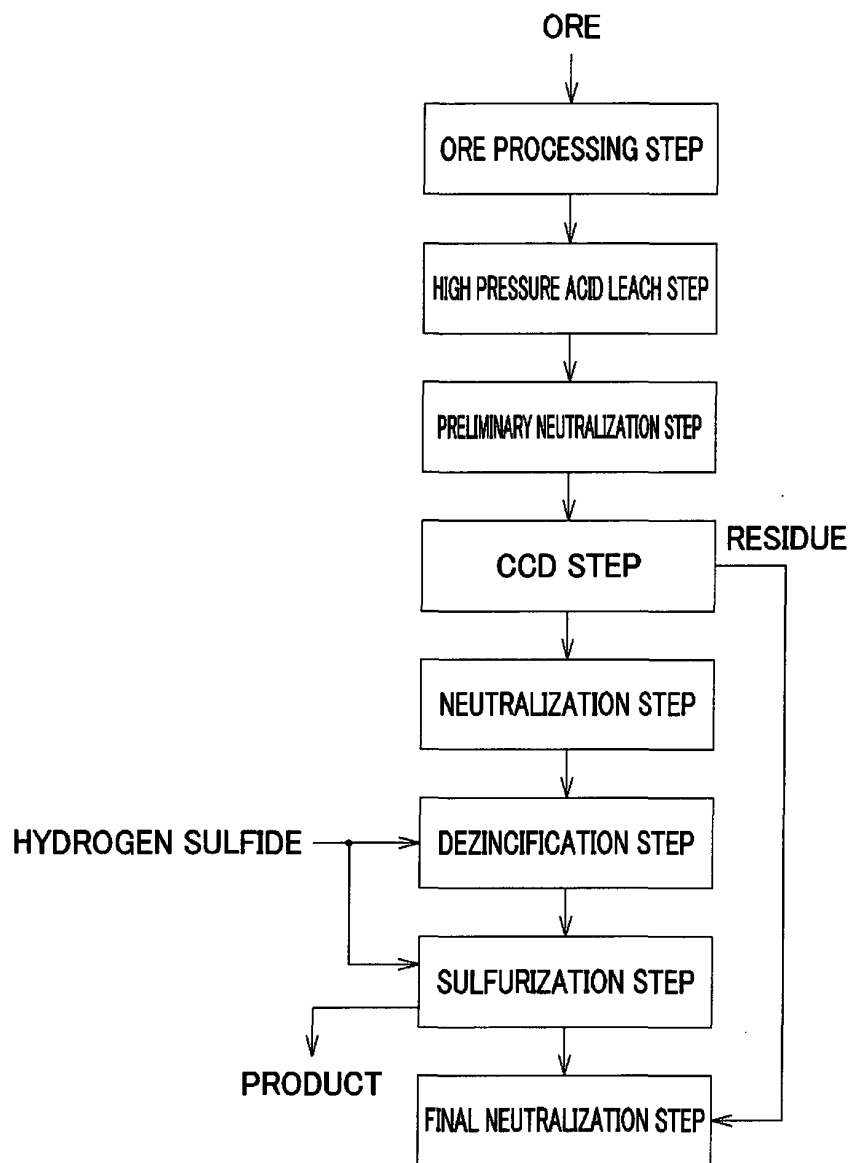


FIG.7

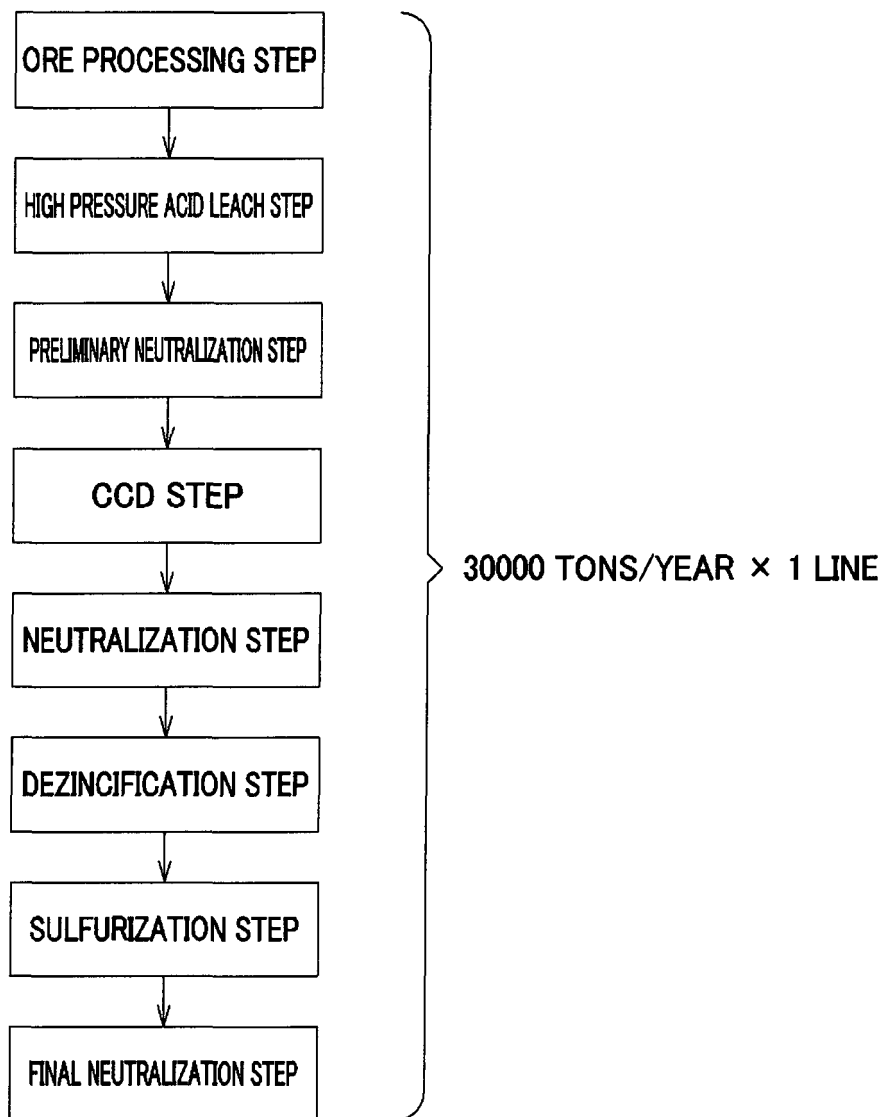


FIG.8

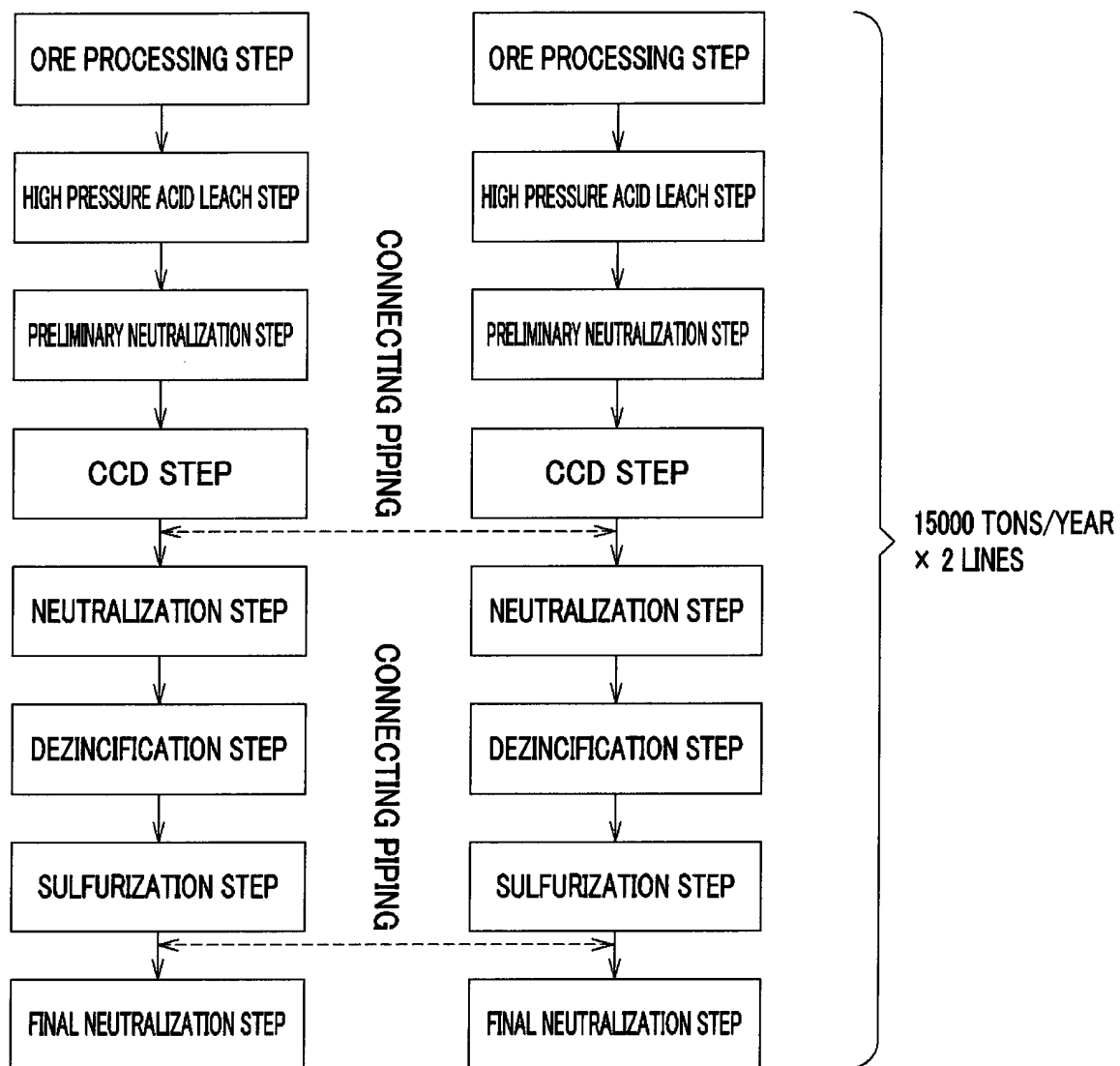


FIG.9

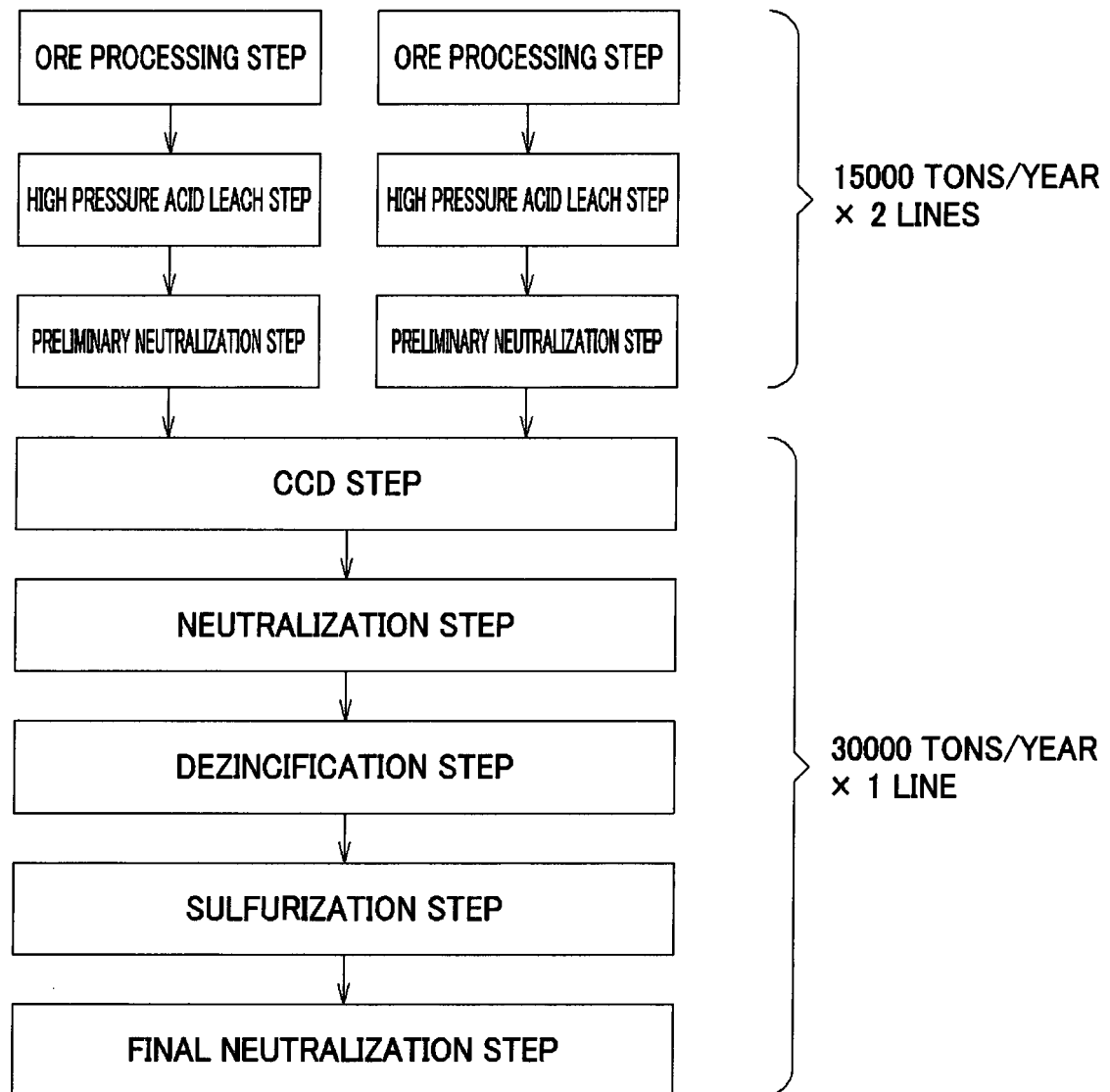


FIG.10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/051319

A. CLASSIFICATION OF SUBJECT MATTER

C22B23/00(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)

C22B23/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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 2012-237030 A (Sumitomo Metal Mining Co., Ltd.), 06 December 2012 (06.12.2012), all pages; all drawings (Family: none)	1-11
A	JP 2012-31446 A (Sumitomo Metal Mining Co., Ltd.), 16 February 2012 (16.02.2012), all pages; all drawings & US 2013/0074653 A1 & EP 2599885 A1 & WO 2012/014685 A1 & CA 2798357 A	1-11
A	JP 2007-77459 A (Pacific Metals Co., Ltd.), 29 March 2007 (29.03.2007), all pages; all drawings (Family: none)	1-11

☐ 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
27 March, 2014 (27.03.14)Date of mailing of the international search report
08 April, 2014 (08.04.14)Name and mailing address of the ISA/
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