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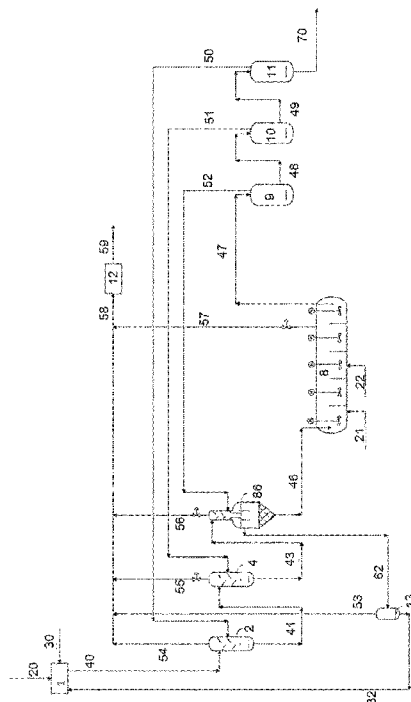
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FIG. 5



(57) Abstract: The invention relates to a method and an arrangement for nickel laterite processing. The method comprises the steps of providing a cold feed slurry; heating cold feed slurry one or more times to obtain a heated diluted feed slurry; removing water from the heated diluted feed slurry to obtain a heated thickened feed slurry; optionally repeating steps (a) and/or (b) until a final heated feed slurry is obtained; and subjecting the final heated feed slurry to pressure acid leach.

ENHANCED METHOD AND ARRANGEMENT FOR LATERITE PROCESSING

FIELD OF THE INVENTION

The present invention is in the field of hydrometallurgical treatment of ores and relates to high pressure acid leaching of laterites providing a method of laterite processing comprising pre-heating of the nickel laterite feed slurry.

BACKGROUND OF THE INVENTION

In extractive metallurgy of nickel laterites, especially of goethitic limonites, high-pressure autoclaves are extensively utilized to allow increased operating temperatures. While high-pressure acid leach (HPAL) processes are efficient and cost effective, the cost of constructing HPAL plants for treating nickel laterites has proven to be very expensive. Large pressure vessels containing acidic solutions and operating at high temperatures require use of large amounts of titanium and other expensive materials at large capital costs. Particularly, the HPAL requires a large amount of energy for heating the ore material and the acid and the hot acidic environment causes wear and tear upon plant and equipment. Due to resulting high energy costs lower grade ores have not been utilized in such processes.

Furthermore, since laterite leaching does not generate energy, as occurs in the leaching of sulfide ores and concentrates, steam must be added to the autoclave to maintain its temperature. To minimize the cost of the steam addition energy recovery is often practiced and flash steam obtained from one or more flash vessels or pressure let-down of the autoclave discharge slurry is typically recycled back into the laterite feed stream for pre-heating the slurry before its entry into the autoclave. Since heating occurs by direct contact the steam condensates into liquid and dilutes the incoming slurry. This significantly increases the volumetric flowrate of the slurry and for a fixed leach residence time the required size of the autoclave increases significantly.

Indirect heating of the slurry before its entry into the autoclave would solve the problem of the dilution of the slurry. However, the tubes of an indirect heater scale very quickly if flash steam obtained from the pressure let-down of the autoclave discharge slurry is utilized in the indirect heater. Further, nickel laterite slurries are notoriously difficult slurries to transport when thickened and due the rheology, the heat transfer co-efficient of these slurries in indirect heater is inherently very low.

BRIEF DESCRIPTION OF THE INVENTION

Accordingly, it is an object of the present invention to provide a hydrometallurgical laterite processing method and an arrangement for implementing the method which reduces the capital and operating costs of nickel laterite processes and allows the utilization of lower grade ores. The objects of the invention are achieved by a method and an arrangement, which are characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the realization that flash steam can be first utilized in direct contact for pre-heating the feed slurry, in which the heated but diluted feed slurry can then be subjected to dewatering step to thicken the hot feed slurry to a more desirable volume. The hot feed slurry is thus obtained from the pre-heating circuit at as high density as possible and the same yield of product can be obtained with lower volumetric flowrate of the incoming slurry. The lower volumetric flowrate of the incoming slurry results in lowered downstream costs as that the size of the autoclave and the feed pumping equipment can be reduced. For example, at the same solid capacity a smaller autoclave is required. Further, the size of any downstream recovery unit, such as a solvent extraction unit or a sulfide precipitation unit, can be reduced and capital cost thus lowered. Also operating costs are significantly reduced in terms of lower amounts of required boiler steam, acid and other consumables.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 illustrates process flow a first example of the method of the present invention;

Figure 2 illustrates process flow a second example of the method of the present invention;

Figure 3 illustrates process flow a third example of the method of the present invention;

Figure 4 illustrates process flow a fourth example of the method of the present invention; and

Figure 5 illustrates process flow a fifth example of the method of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a method of nickel laterite processing, comprising the steps of: (o) providing a cold feed slurry; (a) heating the cold feed slurry one or more times to obtain a heated diluted feed slurry; (b) removing water from the heated diluted feed slurry to obtain a heated thickened feed slurry; (c) optionally repeating steps (a) and/or (b) one or more times until a final heated feed slurry is obtained; and (d) subjecting the final heated feed slurry to a pressure acid leach, in particular high pressure acid leach (HPAL).

10 In accordance with the present invention the cold feed slurry comprises nickel laterite ore and/or concentrate, in particularly goethitic limonite. Typically a nickel laterite ore comprises: SiO_2 from 2 to 20% w/w, Fe from 20 to 60% w/w, Mg from 0.5 to 6% w/w, and Ni from 0.5 to 3% w/w.

The cold feed slurry is typically provided by a slurry preparation step wherein feed material comprising nickel laterite ore and/or concentrate is mixed with an aqueous solution while being milled and prepared. The term "aqueous solution" used herein and hereafter refers to water solutions known to be suitable by the person skilled in the art for use in slurry preparation steps. Such aqueous solution can for example be process water can for example be purified water, natural water, saline water obtained e.g. from sea or saline lakes, or recycled process water obtained from other process steps.

The cold feed slurry typically comprises 20 to 45% w/w nickel laterite ore and/or concentrate, in particular goethitic limonite ore and/or concentrate, and optionally other feed materials. Slurries of most nickel laterites and especially goethitic limonites exhibit non-Newtonian fluid behavior that limits the density where they can be thickened, screened and/or pumped. Typically feed pumping systems are limited to 100 to 200 Pa yield stress slurries which for most laterites represent 35 to 45% w/w solids at ambient temperature.

When the temperature of the slurry is increased the yield stress of the slurry is reduced. Heating in the pre-heating step (a) is thus advantageously preformed so as to reach temperature of the diluted heated feed slurry in case of atmospheric pre-heating from 70 to 100°C, preferably from 80 to 98°C, more preferably from 90 to 95°C, or in the case of pressurized pre-heating above 100°C, preferably from 100 to 160°C, more preferably above 160°C, most preferably from 150 to 200°C, so as to effect maximum reduction in the slurry viscosity and maximize the temperature of the slurry. At this temperature

the viscosity of water and therefore also that of the laterite slurry is lower. Dewatering step (b) is thus preformed to lower the volumetric flowrate to the autoclave. Water can be removed by any suitable dewatering method known to a person skilled in the art, e.g. by solid liquid separator, such as a thickener or pressure decanter.

Lowering the flowrate provides lower feed pumping capital cost, lower autoclave volume and lower downstream nickel recovery processing costs. Furthermore, thickening of the slurry at higher temperature allows increases underflow density and thus provides final feed slurry with increased density as compared to if the final feed slurry was thickened at lower temperatures.

Addition of acid to the autoclave is typically controlled based on the terminal free acid concentration required to promote laterite dissolution. When the density of the final feed slurry is increased the volumetric flow is decreased and also the sulfuric acid consumption of the process is reduced. Decrease of the volumetric flowrate of the final feed slurry will also result in reduction in steam usage. Fresh boiler steam is typically added to autoclave to maintain autoclave temperature. As the density of the final feed is increased less steam is required.

In an example of the present invention water recovered in a dewatering step (b) is recycled back to the preparation of the cold feed slurry from ore and/or concentrate and/or pre-heating of the same before it enters the first pre-heating step (a). This reduces the net water usage of the nickel laterite processing.

In accordance with the present invention steps (a) and (b) can be performed one or more times before step (d). Pre-heating step (a) must be performed at least once before first step (b). However, the first dewatering step (b) can be preceded by multiple steps (a). Also dewatering step (b) must be performed at least once. The heated thickened feed slurry obtained from the first or any further dewatering step (b) can be subjected to one or more, preferably one or two, further steps (a) and/or (b) before step (d).

In an example of the present invention the cold feed slurry is subjected once to a pre-heating step (a) and once to a dewatering step (b) before it is subjected to step (d) as the final heated feed slurry. In a further example of the present invention the first heated thickened feed slurry obtained from the first dewatering step (b) is further heated under pressure in one or more, preferably two, pressurized pre-heating step(s) (a) to obtain a pressurized heated

feed slurry which it is then subjected to step (d) as the final heated feed slurry. If these pressurized pre-heating steps where hot steam comes into direct contact with the feed slurry and which are performed after the first step (b) are not coupled with dewatering step(s) (b) the pressurized heated feed slurry is somewhat diluted as compared to the heated thickened feed slurry obtained by the first dewatering step (b) as it enters the HPAL step (d) as the final heated feed slurry. It is to be noted, however, that the density of the final heated feed slurry is still significantly increased and the volumetric flowrate lower as to a feed slurry introduced into a HPAL step of a conventional process. Thus in a preferred example of the present invention the last dewatering step (b) is performed directly before the HPAL step (d).

Figure 1 shows a process flow of a first example of the method of the present invention. Feed material comprising nickel laterite ore and/or concentrate 20 is fed into a slurry preparation step 1 wherein it is mixed with an aqueous solution 30 to obtain a cold feed slurry 40. The aqueous solution 30 is typically water or process water as discussed above. The obtained cold feed slurry 40 is then introduced into a first pre-heater 2 where the cold feed slurry is contacted with a first hot steam 50 to obtain a first heated diluted feed slurry 41. The first pre-heater 2 is typically operated under atmospheric pressure, at a temperature from 70 to 95°C. The first heated diluted feed slurry 41 is then introduced into a first dewatering unit 3 to obtain a first heated thickened feed slurry 42 and a first recovered hot water 31. The first recovered hot water 31 is advantageously recycled into the slurry preparation step 1 to replace some of the required amount of the aqueous solution 30.

With further reference to Figure 1, the obtained first heated thickened feed slurry 42 could then be directly entered into an autoclave 8 as the final heated slurry. However, in this example the first heated thickened feed slurry 42 is then further heated in a first pressurized pre-heater 4 to obtain a first pressurized heated diluted feed slurry 43 which is then heated in a second pressurized pre-heater 6 to obtain a second pressurized heated diluted feed slurry 45. The second pressurized heated diluted feed slurry is then entered into the autoclave 8 as a final heated feed slurry for pressure acid leaching of step (d). Acid 21 and hot steam 22 required in the leaching step (d) are provided into the autoclave 8 as required. After leaching the thus obtained autoclave discharge slurry 47 is then entered into one or more, here three, flash vessels 9, 10, 11 arranged after the autoclave 8 for pressure let-down of the autoclave

discharge slurry to atmospheric pressure 70. The flash steams 50, 51, 52 consequently obtained from the said flash vessels 9, 10, 11 are utilized as the hot steams required in the pre-heaters 2, 4, 6. Thus the temperature and the pressure of the steam utilized in the pre-heating steps advantageously correspond to the temperature and pressure of the flash-down steps.

Thus in accordance with a preferable example of the present invention the steam utilized in the pre-heating step (a) is flash steam obtained from one or more, preferably three, flash vessels arranged for pressure let-down of the autoclave discharge slurry obtained from step (d).

In a further suitable example of the present invention the cold feed slurry is subjected to a first pre-heating step (a) and a first dewatering step (b) under atmospheric pressure and then to one or more, preferably one or two, further steps (a) and (b) under pressurized conditions before it is entered to step (d) as the final heated feed slurry.

Figure 2 shows a flow diagram of a second example of the method of the present invention wherein the method comprises a first pre-heating step (a) and a first dewatering step (b) under atmospheric pressure and then a second pre-heating step (a) and a second dewatering step (b) under pressurized conditions and a third pressurized pre-heating step (a). In Figure 2, like components are designated by the same reference numerals as used in Figure 1.

Referring to Figure 2, the first heated thickened feed slurry 42 obtained in a similar fashion as described with reference to Figure 1 is introduced into a first pressurized pre-heater 4 wherein it is contacted with a second hot steam 51 to obtain a second heated diluted feed slurry 43. The first pressurized pre-heater 4 is typically operated under 0.5 to 8 bar pressure, at a saturated steam temperature between 110 to 160°C. The second heated diluted feed slurry 43 is then introduced into a first pressurized dewatering unit 5 to obtain a first pressurized heated thickened feed slurry 44 and a first recovered hot water steam 61. The first pressurized heated thickened feed slurry 44 is then introduced into a second pressurized pre-heater 6 wherein it is contacted with a third hot steam 52 to obtain a second pressurized heated diluted feed slurry 45 which is entered into the autoclave 8 for HPAL step (d) as the final heated feed slurry.

Figure 3 shows a flow diagram of a third example of the method of the present invention wherein the method comprises a first pre-heating step (a) and a first dewatering step (b) under atmospheric pressure and then a second

pre-heating step (a) and a second dewatering step (b) and a third pre-heating step (a) and a third dewatering step (b) under pressurized conditions. In Figure 3, like components are designated by the same reference numerals as used in Figure 1 and Figure 2.

5 Referring to Figure 3, the first pressurized heated thickened feed slurry 44 obtained by the first pressurized dewatering unit 5 in a similar fashion as described with reference to Figure 2 is introduced into a second pressurized pre-heater 6 wherein it is contacted with a third hot steam 52 to obtain a second heated diluted feed slurry 45. The second pressurized pre-heater 6 is typi-
10 cally operated under 8 to 22 bar pressure, at a saturated steam temperature between 160 to 200°C. The second heated diluted feed slurry 45 is then introduced into a second pressurized dewatering unit 7 to obtain a second pressurized heated thickened feed slurry 46 and a second recovered hot water steam 63. The second pressurized heated thickened feed slurry 46 is then entered
15 into the autoclave 8 for HPAL step (d) as the final heated feed slurry.

With reference to Figures 2 and 3, the recovered hot water steams 61, 63 can be flashed in a flash vessel 13 and obtained water recycled into the slurry preparation step 1 as a second recovered hot water 32 to further replace some of the required amount of the aqueous solution 30. Flash steam 53 can
20 be re-used by directing it to a scrubber 12.

In accordance with the present invention the dewatering unit operated under ambient pressure is conventional. The pressurized dewatering units utilized for removal of water from pressurized heated diluted slurries are preferably pressure decanters arranged for removal of water added when the
25 thickened heated feed slurry was contacted with the pressurized hot steam.

Further in accordance with the present invention heating and dewatering steps (a) and (b) can be performed either as separate steps in separate process units or as a combined step (a) and (b) in a single process unit. In accordance with a particularly preferred example of the present invention the
30 combined step (a) and (b) is performed in a combined heater-decanter unit.

An example of the combined heater-decanter unit is a combined heater-decanter unit comprising a vertically elongated vessel comprising a heating section arranged in the upper part of the vessel, a pressure decantation section arranged below the heating section and a passage extending from
35 the heating section to the pressure decantation section. The heating section comprises a first inlet for slurry to enter the vessel and a second inlet for heat-

ing fluid to enter the heating section. The pressure decantation section comprises a tapered part for slurry to settle and a first outlet for discharging the slurry.

5 The heating fluid is preferably saturated steam that is fed to the heating section such that it enters the heating section below the point in which the slurry enters the heating section so that the steam flows upward in the heating section and slurry falls downward by gravity in the heating section and at the same time the slurry becomes heated by the saturated steam. In other words the inlet for heating fluid to enter the heating section is in the heating
10 section such that it is below the inlet for slurry to enter the heating section, or in other words it is below the inlet for slurry to enter the vessel. The inlet for slurry is referred as a first inlet and the inlet for heating fluid is referred as a second inlet in this application. The heating section preferably comprises an outlet for excess heating fluid, preferably excess steam, to be released away from the
15 vessel. The excess steam is preferably released under pressure control through a stream in the top part of the heating section. The excess heating fluid is the heating fluid that has not condensed on the cold slurry and becomes useless.

The heating section comprises at least one gas-liquid contact surface which can be made as an integral part of the vessel or as a separately
20 attached part. The gas-liquid surface is preferably a tray or a plate which is arranged in the heating section such that the cold slurry that has entered the heating section flows by gravity over the gas-liquid surface or a series of gas-liquid surfaces and during flow of said cold slurry that comprises liquid a contact is formed between the slurry and said steam to effect heat exchange there
25 between. The steam also heats the gas-liquid surfaces that promote heating of said slurry.

The pre-heated slurry that is heated in the heating section flows through a passage to the pressure decantation section. The pressure decanta-
30 tion section forms the lower part of the vertically elongated vessel and comprises a part that is tapered or that has a section comprising inclined sides that make an angle between 30 to 60° from the horizontal. In the pressure decantation section the heated slurry settles and thickens, especially when the tapered space forms sufficient static head to promote dewatering under the weight of
35 the settled solids and a relatively clean overflow is generated. The thicker slurry in the bottom part of the pressure decantation section is eventually dis-

charged through a first outlet for discharging said slurry. The overflow liquid that has generated on the settled slurry can be discharged through a second outlet in the upper part of the pressure decantation section for discharging overflow liquid.

5 The passage between the heating section and the pressure decantation section is preferably a down comer pipe that extends from the lower part of the heating section to the pressure decantation section and preferably to the midway of the pressure decantation section such that the incoming slurry is directed into the settled solids bed via said pipe such a way that the settled solids act as a clarifier for the overflow solution.

10 The vessel may also comprise a rake in the pressure decantation section to promote solids dewatering.

 Figure 4 shows a flow diagram of a fourth example of the method of the present invention wherein the method comprises a first combined step (a) and (b) under atmospheric pressure and a second combined step (a) and (b) and a third combined step (a) and (b) under pressurized conditions. In Figure 4, like components are designated by the same reference numerals as used in Figure 1, Figure 2 and Figure 3.

 Referring to Figure 4 a cold feed slurry 40 obtained from the slurry preparation step 1 in a similar fashion as described with reference to Figure 1 is introduced into a first combined heater-decanter unit 82 wherein the cold feed slurry is first contacted with a first hot steam 50 to obtain a first heated diluted feed slurry which then enters the decanter section of the said heater-decanter unit to obtain a first heated thickened feed slurry 42 and a first recovered hot water 31. The first recovered hot water 31 is advantageously recycled into the slurry preparation step 1 as discussed above.

 With further reference to Figure 4, the obtained first heated thickened feed slurry 42 is then introduced into a first pressurized combined heater-decanter unit 84 wherein it is first contacted with a second hot steam 51 to obtain a second diluted heated feed slurry which then enters the decanter section of the said heater-decanter unit to obtain a first pressurized heated thickened feed slurry 44 and a first recovered hot water steam 61. The first pressurized combined heater decanter unit 84 is typically operated under 0.5 to 8 bar pressure, at a saturated steam temperature between 110 to 160°C. The first pressurized thickened heated feed slurry 44 is then introduced into a second pressurized combined heater-decanter unit 86 wherein it is contacted with a third

hot steam 52 to obtain a third heated diluted feed slurry which then enters the decanter section of the said heater-decanter unit to obtain a second recovered hot water steam 62 and a second pressurized heated thickened feed slurry 46. The second pressurized heated thickened feed slurry 46 is then entered as a final heated feed slurry into the autoclave 8 for pressure acid leach step (d). The recovered hot water steams 61, 63 can be flashed in a flash vessel 13 and obtained water is recycled into the slurry preparation step 1 as a second recovered hot water 32 as discussed above. Flash steam 53 is directed to the scrubber 12.

In an alternative example of the present invention the cold feed slurry is subjected one or more times, preferably once, to pre-heating step (a) under atmospheric conditions to obtain a heated diluted feed slurry and then the obtained heated diluted feed slurry is further heated under pressure in one or more, preferably one or two, pressurized pre-heating step(s) (a) to obtain a pressurized heated diluted feed slurry. The pressurized heated diluted feed slurry is then subjected to at least one dewatering step (b) to obtain a pressurized heated thickened feed slurry which is then subjected to HPAL step (d) as the final heated feed slurry. Typically in accordance with this example only one dewatering step (b) is required before the feed slurry can be introduced into the HPAL step (d). Preferably in accordance with this example the last pressurized pre-heating step (a) and the consecutive first pressurized dewatering step (b) is a combined pressurized step (a) and (b). This allows the most efficient pre-heating and dewatering of the feed slurry.

Figure 5 shows a flow diagram of a fifth example of the method of the present invention wherein the method comprises a first pre-heating step (a) under atmospheric pressure and a second pre-heating step (a) under pressurized conditions, followed by a first combined step (a) and (b) under pressurized conditions. In Figure 5, like components are designated by the same reference numerals as used in Figure 1, Figure 2, Figure 3, and Figure 4.

Referring to Figure 5 the cold feed slurry 40 obtained from the slurry preparation step 1 in a similar fashion as described with reference to Figure 1 is heated in a first pre-heater 2 wherein it is contacted with a first hot steam 50 to obtain a first heated diluted feed slurry 41 which is then further heated in a first pressurized pre-heater 4 wherein it is contacted with a second hot steam 51 to obtain a first pressurized heated diluted feed slurry 43. The first pressurized heated diluted feed slurry 43 is then introduced into a first combined pres-

surized heater-decanter unit 86 where the first pressurized heated diluted feed slurry 43 is first contacted with a third hot steam 52 to obtain a second pressurized heated diluted feed slurry which then enters the decanter section of the said heater-decanter unit to obtain a first recovered hot steam 62 and a first heated thickened feed slurry 46 slurry which is then subjected to HPAL step (d) as the final heated feed slurry. The first recovered hot water steam 62 can be flashed in a flash vessel 13 and obtained water 32 recycled into the slurry preparation step 1 as a recovered hot water stream 32 as discussed above. The flash steam 53 can be directed to the scrubber 12.

With reference to Figures 1 to 5, the off-gas(es), i.e. steams, 53, 54, 55, 56 produced by the pre-heating unit(s) 2, 4, 6, the combined heater-decanter unit(s) 82, 84, 86, and/or the flash vessel 13 can be combined 58 and cleaned in one or more cleaning unit(s), e.g. scrubber(s), 12 by any suitable methods known to a person skilled in the art to obtain a cleaned off-gas, i.e. steam, 59 which thereafter can be released to the atmosphere.

The final heated feed slurry entering the HPAL step (d) advantageously contains 40 to 60% w/w ore and/or concentrate, and optionally other feed materials. After a single round of steps (a) and (b) the temperature of the thickened heated feed slurry entering the HPAL step (d) is typically from 70 to 100°C, preferably from 80 to 95°C, more preferably from 90 to 95°C. After multiple steps (a) and (b) the temperature of the final heated feed slurry entering the HPAL step (d) is typically from 160 to 210°C, preferably from 180 to 200°C.

In an example of the arrangement of the present invention the arrangement further comprising a flash vessel 11 connected to the autoclave 8 for receiving an autoclave discharge slurry 1 provided by the autoclave 8 and arranged for converting heat of the autoclave discharge slurry into a flash steam and a cooled discharge slurry. In a further example of the arrangement of the present invention the flash vessel 9 is connected to the heating unit 2 for providing the flash steam to the heating unit as the hot steam contacted with the cold feed slurry. In yet a further example of the arrangement of the present invention the arrangement further comprising one or more further heating unit(s). In a still further example of the arrangement of the present invention the arrangement further comprising one or more further dewatering unit(s).

In a preferred example of the arrangement of the present invention the arrangement one or more of the consecutive heating unit(s) and dewatering unit(s) is replaced by combined heater-decanter unit(s) arranged for first contacting the feed slurry with a hot steam to obtain a heated diluted feed slurry and dewatering the diluted heated feed slurry as it enters the decanter section of the heater-decanter unit to obtain a heated thickened feed slurry.

The present invention also relates to an arrangement for nickel laterite processing, comprising a first pre-heating unit for receiving a cold feed slurry and arranged for contacting the cold feed slurry with a first hot steam to obtain a first heated diluted feed slurry; optionally one or more further pre-heating units arranged after the first pre-heating unit for contacting heated feed slurry with a further hot steam to obtain a further heated diluted feed slurry; a first dewatering unit arranged between any two pre-heating units or after the last pre-heating unit for receiving heated diluted feed slurry from the preceding pre-heating unit and arranged for removing water from the said heated diluted feed slurry to obtain a first heated thickened feed slurry; optionally one or more further dewatering unit(s) arranged between any two heating unit(s) or after the last pre-heating unit to obtain a further heated thickened feed slurry; wherein the first and optional further pre-heating units and the first and optional further dewatering unit(s) are arranged for obtaining a final heated feed slurry from the last pre-heating unit or dewatering unit, which ever comes last downstream in the arrangement; and an autoclave arranged after the said last pre-heating unit or dewatering unit for receiving the final heated feed slurry and adapted for pressure leaching of the same to obtain an autoclave discharge slurry.

In a particular example of the arrangement of the present invention the arrangement is adapted for performing the method of the present invention as defined above.

In a typical example of the arrangement of the present invention the arrangement further comprises one or more flash vessel(s) connected to the autoclave in series for receiving the autoclave discharge slurry and arranged for converting heat of the autoclave discharge slurry into one or more flash steam(s), respectively, and obtaining a cooled discharge slurry. In accordance with this example the last flash vessel is preferably connected to the first pre-heating unit for providing the last flash steam to the said pre-heating unit to be utilized as the hot steam contacted with the cold feed slurry. Furthermore, the arrangement typically comprises equal amount of pre-heating units and flash

vessels. The first flash vessel is typically connected to the last flash vessel. Any further flash vessels between the first flash vessel and the last flash vessel are connected to respective further pre-heating units between the last pre-heating unit and the first pre-heating unit respectively in reverse order.

5 In a suitable example of the arrangement of the present invention the arrangement comprises one or more, preferably two, further pre-heating unit(s) between the first heater unit and the first dewatering unit. In a further typical example of the arrangement of the present invention the arrangement comprises one or more, preferably two, further pre-heating unit(s) between the
10 first dewatering unit and the autoclave. In another suitable example of the arrangement of the present invention the arrangement comprises one or more, preferably one or two, further dewatering unit(s). In a still another typical example of the arrangement of the present invention the arrangement comprises one or more, preferably two, further pre-heating unit(s) and one or more, preferably one or two further dewatering unit(s).
15

 In a particular example of the present invention the arrangement comprises two further pre-heating units arranged after the first dewatering unit and one further dewatering unit arranged after the second pre-heating unit.

 As discussed above, in accordance with the present invention step
20 pre-heating step (a) and dewatering step (b) can be performed in a single process unit. Thus in accordance with a preferable example of the present invention least one consecutive pre-heating unit and dewatering unit taken together is a combined heater-decanter unit arranged for first contacting the incoming feed slurry with hot steam to obtain a diluted heated feed slurry and then removing water the heated diluted feed slurry as it enters the decanter section of
25 the said heater-decanter unit to obtain a heated thickened feed slurry.

 In one particularly suitable aspect of this example the first dewatering unit it arranged after the first pre-heating unit and taken together are a first combined heater-decanter unit and the arrangement further comprises one or
30 more, preferably two, combined heater-decanter units arranged after the first combined heater-decanter unit. An alternative particularly suitable aspect of this example the arrangement comprises one or more, preferably two, further pre-heating units between the first pre-heating unit and the first dewatering unit and the last further pre-heating unit and the first dewatering unit taken together
35 is a first combined heater-decanter unit.

Specific examples of the arrangement of the present invention are discussed above in context of the method of the present invention and with reference to Figures 1 to 5.

EXAMPLES

5 **Example 1**

With reference to Figure 1 the following example illustrates by estimation the density increase that can be expected from enhanced laterite processing. Mass and energy balance calculations for a 37% w/w (20°C basis) laterite feed using conventional technology (CLP) and for 47 w/w (95°C basis) laterite feed using enhanced laterite processing (ELP) were performed.

In CLP the slurry is subjected to three direct contact pre-heating steps, first at atmospheric pressure, second at 6 bar and third at 20 bar. In the ELP the slurry is subject to one direct contact pre-heating step at atmospheric pressure coupled with a dewatering step and to two subsequent direct contact pre-heating steps, first at 6 bar and second at 20 bar.

Autoclave Feed Volumetric Flowrate

CLP 947 m³/h

ELP 587 m³/h

20 Reduction with ELP 38%

Hence potential reduction of 38% in feed pump and autoclave size

Acid Usage

CLP 83 t/h

25 ELP 66 t/h

Reduction with ELP 20%

Limestone Usage

This saving is directly related to acid saving. The less excess acid to be neutralized the less neutralant required.

Reduction with ELP 20%

Steam Usage

CLP 62 t/h

ELP 36 t/h

Reduction with ELP 42%

5

Last Flash Vessel Discharge FlowrateCLP 677 m³/hELP 419 m³/h

Reduction with ELP 38%

10

Last Flash Vessel Nickel Concentration

CLP 6.8 g/L

ELP 11.6 g/L

Increase in nickel concentration with ELP 41%

15

Water UsageCLP 349 m³/hELP 127 m³/h

Reduction with ELP 64%

20 **Example 2**

With reference to Figure 5, the following example illustrates by estimation the density increase that can be expected from preferred enhanced laterite processing. Mass and energy balance calculations for a 37% w/w (20°C basis) laterite feed using conventional technology (CLP) and for 47 w/w (95°C basis) laterite feed using enhanced laterite processing (ELP) were performed.

In CLP the slurry is subjected to three direct contact pre-heating steps, first at atmospheric pressure, second at 3 bar and third at 15 bar. In the ELP the slurry is subject to two direct contact pre-heating step at atmospheric pressure and a final combined pre-heating and dewatering step conducted under pressure.

30

Autoclave Feed Volumetric FlowrateCLP 947 m³/hELP 488 m³/h

Reduction with ELP 48%

5 Hence potential reduction of 48% in feed pump and autoclave size

Acid Usage

CLP 83 t/h

ELP 64 t/h

10 Reduction with ELP 23%

Limestone Usage

This saving is directly related to acid saving. The less excess acid to be neutralized the less neuralent required.

15 Reduction with ELP 23%

Steam Usage

CLP 62 t/h

ELP 50 t/h

20 Reduction with ELP 19%

Last Flash Vessel Discharge FlowrateCLP 677 m³/hELP 373 m³/h

25 Reduction with ELP 45%

Last Flash Vessel Nickel Concentration

CLP 6.8 g/L

ELP 13.3 g/L

30 Increase in nickel concentration with ELP 49%

Water UsageCLP 349 m³/hELP 89 m³/h

35 Reduction with ELP 75%

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A method of nickel laterite processing, comprising the steps of
 - (o) providing a cold feed slurry;
 - (a) heating cold feed slurry one or more times to obtain a heated di-
5 luted feed slurry;
 - (b) removing water from the heated diluted feed slurry to obtain a heated thickened feed slurry;
 - (c) optionally repeating steps (a) and/or (b) until a final heated feed slurry is obtained; and
 - 10 (d) subjecting the final heated feed slurry to pressure acid leach, in particular to high pressure acid leach (HPAL).
2. The method as claimed in claim 1, wherein the cold feed slurry contains 20 to 45% w/w nickel laterite ore and/or concentrate, preferably goethitic limonite ore and/or concentrate, and optionally other feed materials.
- 15 3. The method as claimed in claim 1 or 2, wherein the final heated feed slurry entering the HPAL step (d) comprises 40 to 60% w/w ore and/or concentrate, and optionally other feed materials.
4. The method as claimed in any one of claims 1 to 3, wherein the temperature of the final heated slurry entering the step (d) is from 70 to 100°C,
20 preferably from 80 to 95°C, more preferably from 90 to 95°C.
5. The method as claimed in any one of claims 1 to 4, wherein the cold feed slurry is subjected once to a pre-heating step (a) and once to a dewatering step (b) before it is subjected to step (d) as the final heated feed slurry.
6. The method as claims in claim 5, wherein the first thickened
25 heated feed slurry obtained from the first dewatering step (b) is further heated under pressure in one or more, preferably two, pressurized pre-heating steps (a) to obtain a pressurized thickened heated feed slurry which it is then subjected to step (d) as the final heated feed slurry.
7. The method as claims in any one of claims 1 to 4, wherein the
30 cold feed slurry is subjected to a first pre-heating step (a) and a first dewatering step (b) under atmospheric pressure and then to one or more, preferably one or two, further steps (a) and (b) under pressurized conditions before it is entered to step (d) as the final heated feed slurry.

8. The method as claimed in any one of claims 1 to 7, wherein water recovered from the dewatering step (b) is recycled back to the preparation of the cold feed slurry from ore and/or concentrate and/or pre-heating of the same before it enters the first pre-heating (a).

5 9. The method as claimed in any one of claims 1 to 8, wherein the steam utilized in the heating step(s) (a) is obtained from flash steam obtained from one or more, preferably three, flash vessels arranged for pressure let-down of the autoclave discharge slurry obtained from step (d).

10 10. An arrangement for nickel laterite processing, comprising
a first pre-heating unit for receiving a cold feed slurry and arranged for contacting the cold feed slurry with a first hot steam to obtain a first heated diluted feed slurry;

15 optionally one or more further pre-heating units arranged after the first pre-heating unit for contacting heated feed slurry with a further hot steam to obtain a further heated diluted feed slurry;

 a first dewatering unit arranged between any two pre-heating units or after the last pre-heating unit for receiving heated diluted feed slurry from the preceding pre-heating unit and arranged for removing water from the said heated diluted feed slurry to obtain a first heated thickened feed slurry;

20 optionally one or more further dewatering unit(s) arranged between any two heating unit(s) or after the last pre-heating unit to obtain a further heated thickened feed slurry;

 wherein at least one consecutive pre-heating unit and dewatering unit taken together is a combined heater-decanter unit arranged for first contacting the incoming feed slurry with hot steam to obtain a diluted heated feed slurry and then removing water the heated diluted feed slurry as it enters the decanter section of the said heater-decanter unit to obtain a heated thickened feed slurry;

25 wherein the first and optional further pre-heating units and the first and optional further dewatering unit(s) are arranged for obtaining a final heated feed slurry from the last pre-heating unit or dewatering unit, which ever comes last downstream in the arrangement; and

30 an autoclave arranged after the said last pre-heating unit or dewatering unit for receiving the final heated feed slurry and adapted for pressure leaching of the same to obtain an autoclave discharge slurry.
35

11. The arrangement according to claim 10 adapted for performing the method defined in any one of claims 1 to 9.

12. The arrangement as claimed in claim 10 or 11, further comprising one or more flash vessel(s) connected to the autoclave in series for receiving the autoclave discharge slurry and arranged for converting heat of the autoclave discharge slurry into one or more flash steam(s), respectively, and obtaining a cooled discharge slurry.

13. The arrangement as claimed in claim 12, wherein the last flash vessel is connected to the first pre-heating unit for providing the last flash steam to the said pre-heating unit to be utilized as the hot steam contacted with the cold feed slurry.

14. The arrangement as claimed in any one of claims 10 to 13, comprising one or more, preferably two, further pre-heating unit(s) between the first heater unit and the first dewatering unit.

15. The arrangement as claimed in any one of claims 10 to 14, comprising one or more further, preferably two, pre-heating unit(s) between the first dewatering unit and the autoclave.

16. The arrangement as claimed in claim 15, comprising one or more, preferably one or two, further dewatering unit(s).

17. The arrangement as claimed in claim 16, wherein the arrangement comprises two further pre-heating units arranged after the first dewatering unit and one further dewatering unit arranged after the second pre-heating unit.

18. The arrangement as claimed in any one of claims claim 10 to 17, wherein the first dewatering unit is arranged after the first pre-heating unit and taken together are a first combined heater-decanter unit and the arrangement further comprises one or more, preferably two, combined heater-decanter units arranged after the first combined heater-decanter unit.

19. The arrangement as claimed in any one of claims claim 10 to 17, wherein the arrangement comprises one or more, preferably two, further pre-heating units between the first pre-heating unit and the first dewatering unit and the last further pre-heating unit and the first dewatering unit taken together is a first combined heater-decanter unit.

$1/5$

FIG. 1

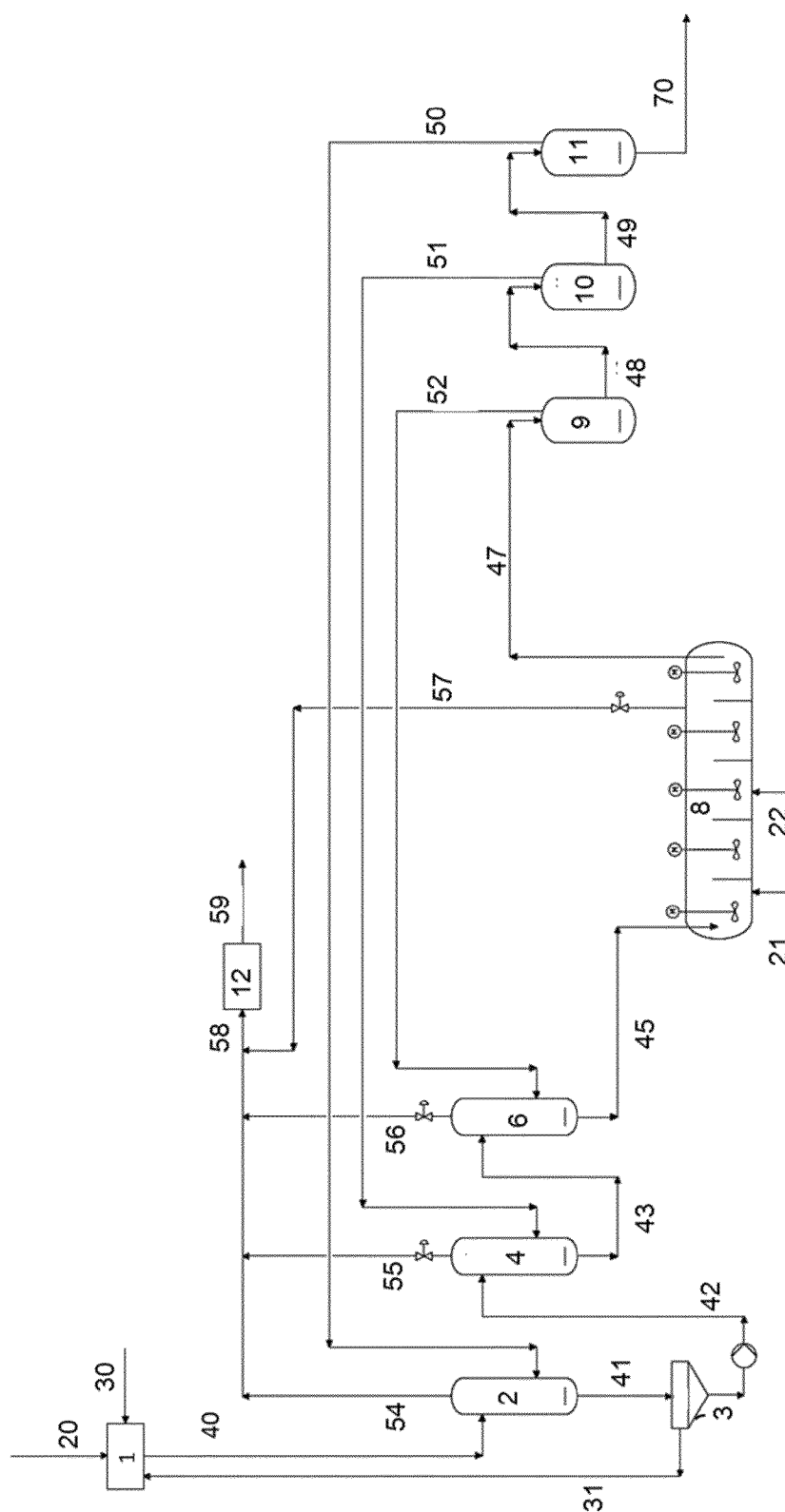


FIG. 2

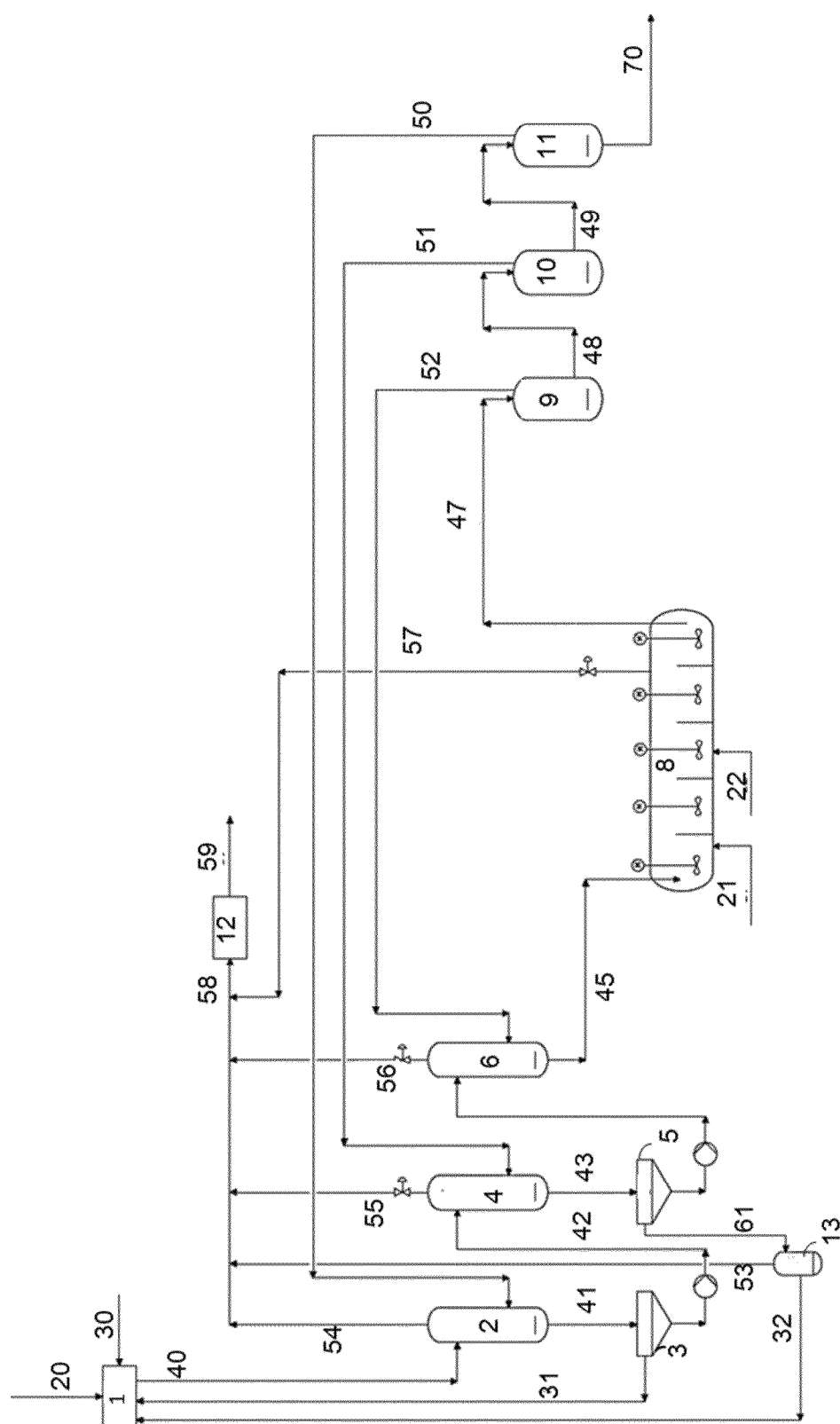


FIG. 3

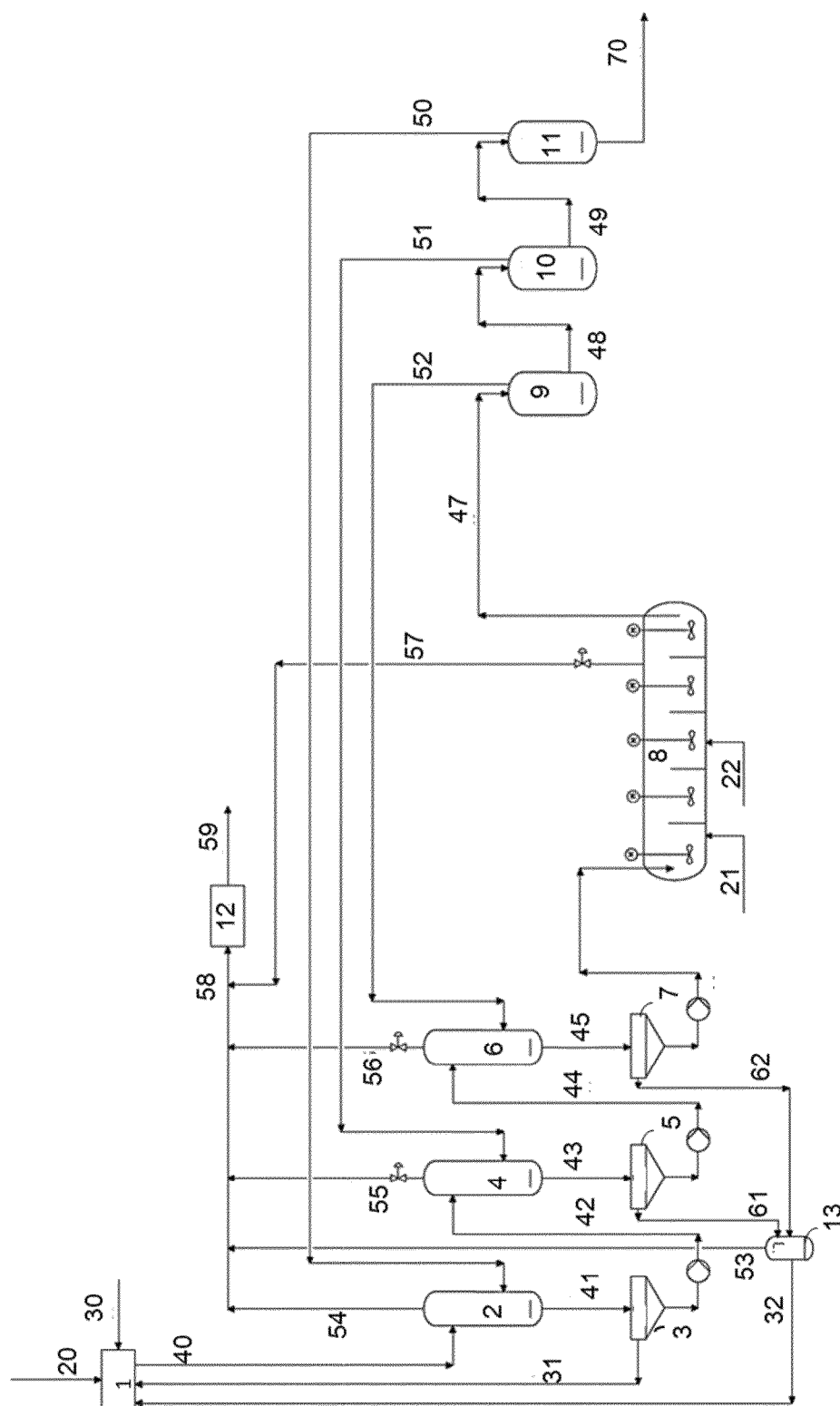


FIG. 4

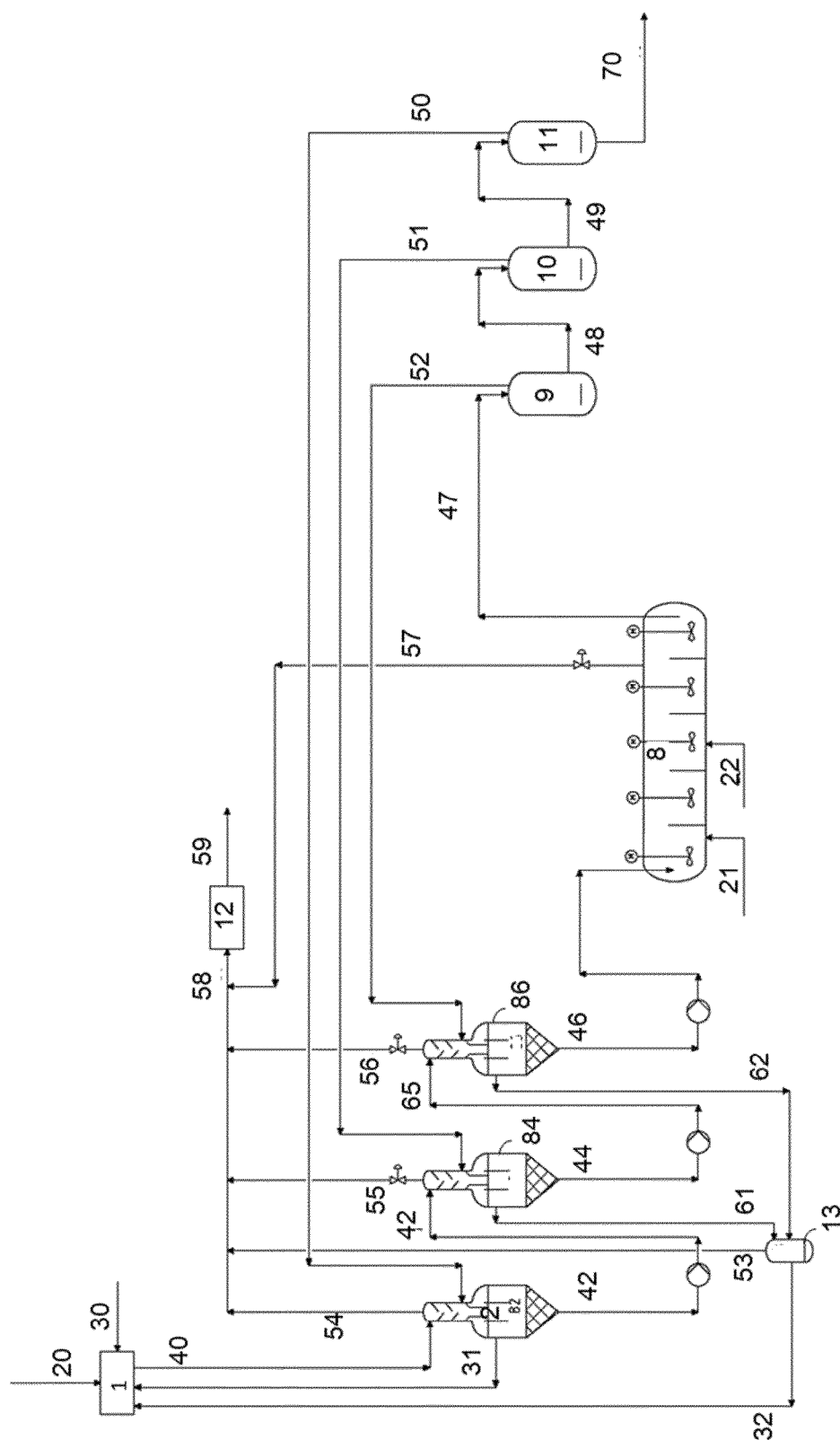
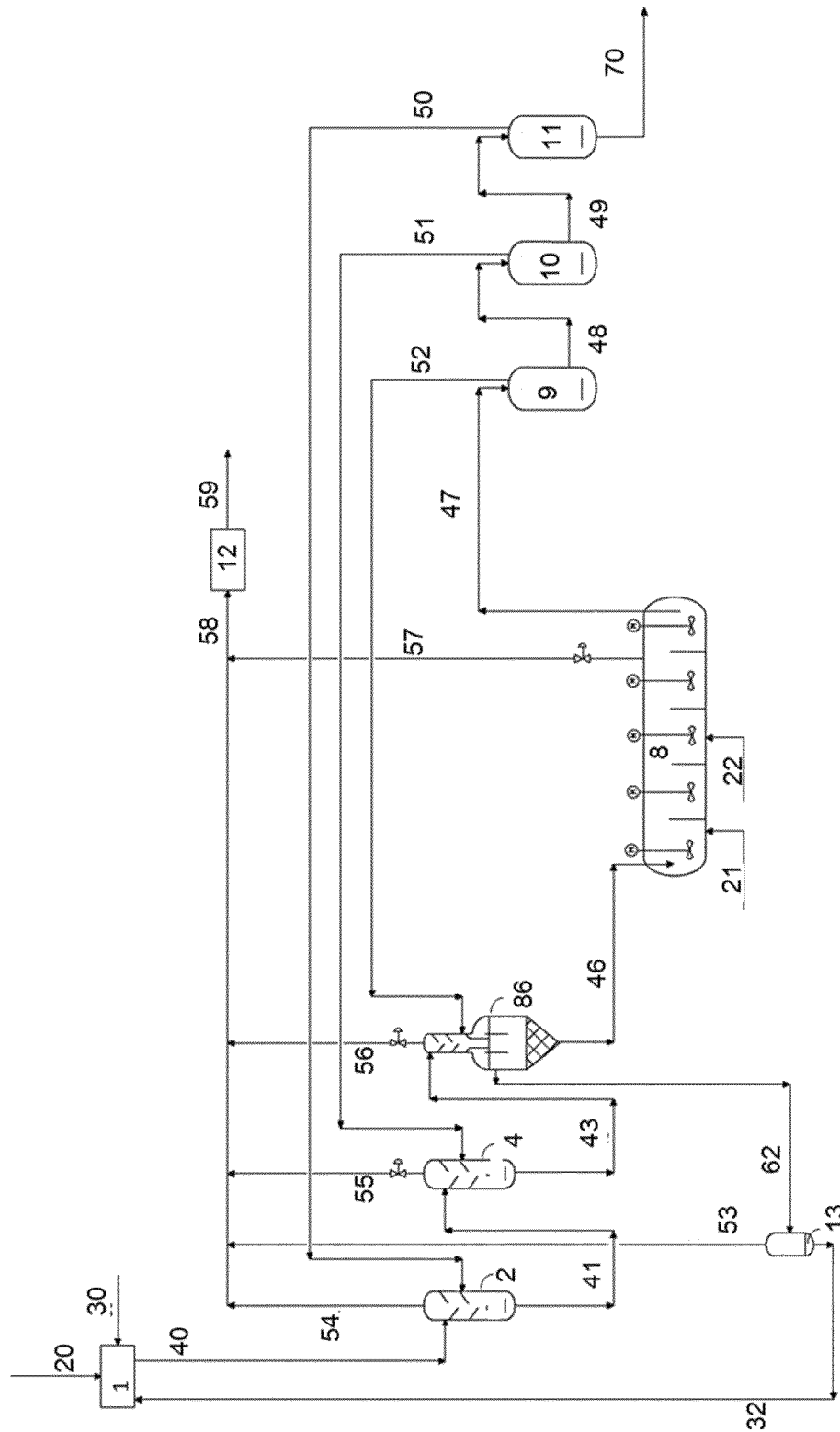


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2014/051041

A. CLASSIFICATION OF SUBJECT MATTER
INV. C22B3/00 C22B23/00
ADD.

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)
C22B

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

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 798 804 A (SIMONS COURTNEY S) 9 July 1957 (1957-07-09) the whole document -----	1-19
A	US 4 098 870 A (FEKETE SIMON O ET AL) 4 July 1978 (1978-07-04) the whole document -----	1-19
A	KING M G: "NICKEL LATERITE TECHNOLOGY - FINALLY A NEW DAWN?", J O M, SPRINGER NEW YORK LLC, UNITED STATES, vol. 57, no. 7, 1 July 2005 (2005-07-01), pages 35-39, XP001244012, ISSN: 1047-4838, DOI: 10.1007/S11837-005-0250-7 the whole document -----	1-19



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

9 March 2015

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19/03/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2014/051041

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