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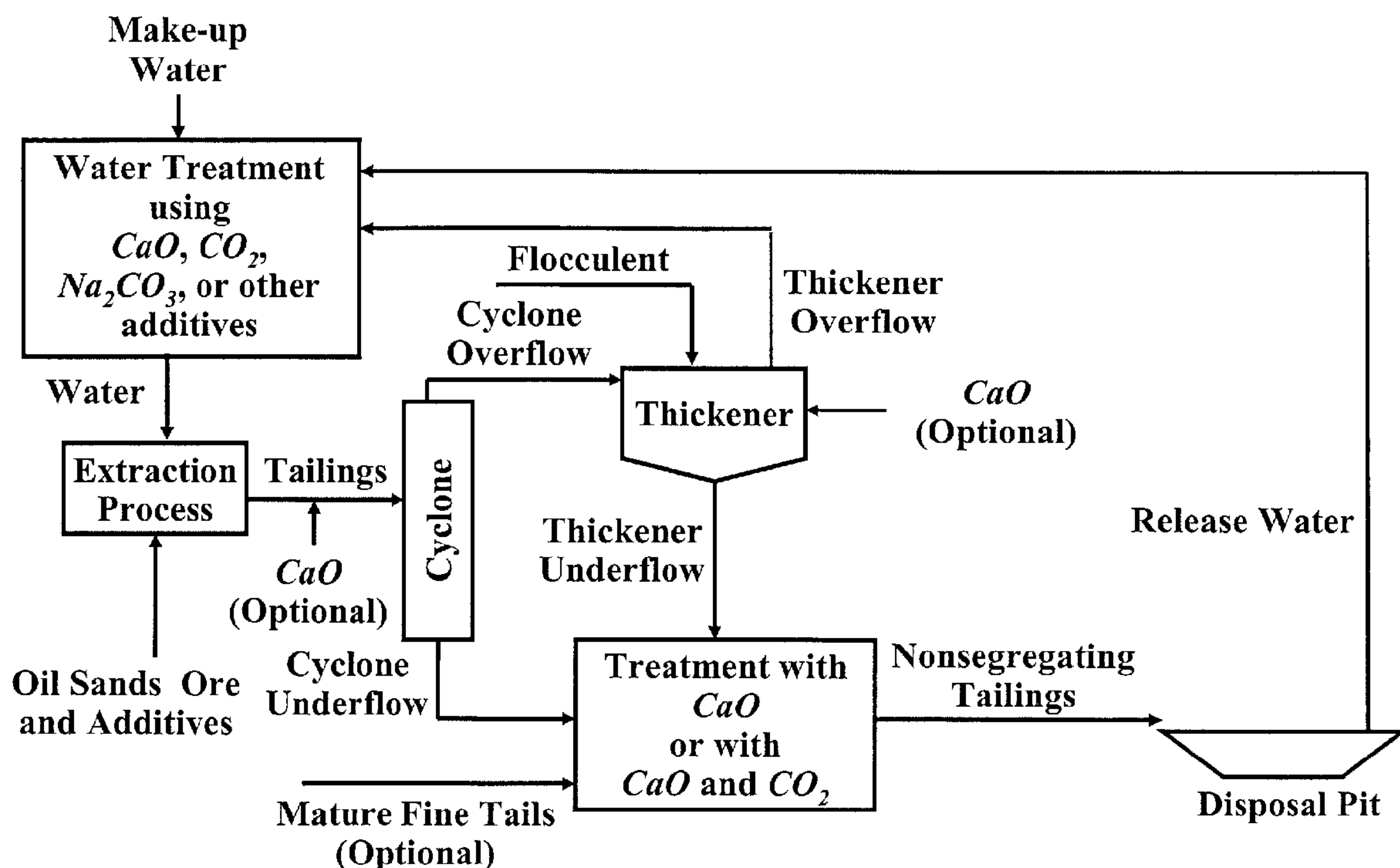
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(54) Titre : METHODE DE TRAITEMENT DE RESIDUS DE SABLES BITUMINEUX A L'AIDE DE CHAUX OU DE CHAUX
ET DE DIOXYDE DE CARBONE

(54) Title: METHOD FOR TREATMENT OF OIL SANDS TAILINGS WITH LIME OR WITH LIME AND CARBON DIOXIDE



(57) Abrégé/Abstract:

The present invention relates to the treatment of oil sands tailings with CaO lime or with CaO lime and CO₂, to achieve improved non-segregating consolidation of the solids in the tailings, and to recover the release water with acceptable chemical properties for its use in the bitumen extraction process. Non-segregating tailings are produced from the blend of cyclone underflow and thickener underflow, or from the blend of cyclone underflow, thickener underflow, and mature fine tails, by treating the tailings mix with CaO or CaO and CO₂ at proper dosages, with the resultant simultaneous production of release water having lower concentrations of Ca²⁺, Mg²⁺, Na⁺, Cl⁻ ions, ultra fines, and color- making organic species concentrations.

ABSTRACT OF THE DISCLOSURE

5 The present invention relates to the treatment of oil sands tailings with *CaO* lime or
with *CaO* lime and *CO*₂, to achieve improved non-segregating consolidation of the solids in
the tailings, and to recover the release water with acceptable chemical properties for its use
in the bitumen extraction process. Non-segregating tailings are produced from the blend of
cyclone underflow and thickener underflow, or from the blend of cyclone underflow,
thickener underflow, and mature fine tails, by treating the tailings mix with *CaO* or *CaO* and
10 *CO*₂ at proper dosages, with the resultant simultaneous production of release water having
lower concentrations of *Ca*²⁺, *Mg*²⁺, *Na*⁺, *Cl*⁻ ions, ultra fines, and color-making organic
species concentrations.

METHOD FOR TREATMENT OF OIL SANDS TAILINGS WITH LIME OR WITH LIME AND CARBON DIOXIDE

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FIELD OF THE INVENTION

The present invention is directed to methods for the treatment of oil sands tailings to achieve non-segregating consolidation of the solids in the tailings, and to recover the release water with acceptable chemical properties for its use in the bitumen extraction process.

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BACKGROUND OF THE INVENTION

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Over 700,000 barrels of synthetic crude oil are produced daily by commercial plants engaged in surface mining of Athabasca oil sands in Northern Alberta. At these plants, bitumen is extracted from oil sands using caustic and non-caustic water slurry-based extraction processes. An average sample of surface-mineable Athabasca oil sand ore contains about 11% bitumen (by weight), 3-6% water, 12% fines (less than 44 microns) and 72% sand.

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Water slurry-based extraction processes use large volumes of water: the production of each cubic meter of bitumen produced require about 7 to 9 cubic meters of water, of which about 70% is recycled from the surface zone of the tailings pond. In this process, about 0.3 cubic meters of water per ton of oil sands feed is withdrawn from the Athabasca River. Commercial plants operating in the Athabasca oil sands must comply with regulatory requirements which stipulate no discharge of process-affected water. As a result of this “zero discharge” policy, waste water containment ponds are formed and waste water (including drainage and other sources) and tailings are discharged into these ponds.

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During the extraction of bitumen from the oil sands by water slurry-based extraction processes, a coarse tailings stream is produced in the form of a slurry, containing about 55% solids (by weight), of which about 82% is sand, about 17% is fines smaller than 44 microns in diameter, and about 1% is unrecovered bitumen.

In early tailings disposal practice, the oil sands tailings discharged from the extraction plant were hydraulically transported and deposited in the tailings ponds. In this process, the coarse sand particles segregate quickly and form a beach. The remaining fine tails of 6 to 10 percent weight accumulate in the tailings ponds. Fine tails settle quickly, forming a suspension of 20 percent weight solids content and over a few years to 30 percent weight solids (85 percent water by volume) with a stable slurry structure, which is called mature fine tails (also called MFT). Mature fine tails remain in a fluid state for centuries because of their very slow consolidation rate. It is predicted that if the conventional tailings disposal practice is continued, the accumulated volume of mature fine tails will increase from the current level of 325 million cubic meters to over 1 billion cubic meters by the year 2020. Accumulation of large volumes of mature fine tails with a very stable fluid structure creates environmental concerns and a long-term environmental liability.

To eliminate formation of the mature fine tails, or to reduce the inventory of the existing mature fine tails, a method was developed to produce a nonsegregating tailings mix (also called consolidated tailings or composite tailings or CT) for the disposal of the oil sands tailings. In this method, the coarse tailings are passed through cyclones, the sand-rich cyclone underflow (typically having at least about 90% sand) is blended with the mature fine tails (comprising about 30-33% solids, which in turn comprise about 98% fines) to produce a nonsegregating mix for final disposal. In this process, chemical additives such as gypsum ($CaSO_4$) are used to prevent segregation. Also in this process, the fines-rich cyclone overflow (with about 20-30% solids, comprising about 50% fines) is discharged to a tailings pond. The fines in the cyclone overflow stream also form the mature fine tailings, which is a concern for long-term operations.

As low-temperature or low-energy bitumen extraction processes became adopted by commercial plants, it became desirable to achieve fast recovery of the process water from the tailings stream to save thermal energy. As a result, the cyclone overflow stream was thickened in thickeners, with the help of preferably polymeric flocculent. Disposal of thickener underflow and cyclone underflow in an environmentally acceptable manner remains the challenge for the oil sands industry.

SUMMARY OF THE INVENTION

The present invention is based on the treatment of oil sands tailings, produced from a process involving water slurry-based extraction of bitumen from oil sand, with lime ($Ca(OH)_2$) or with lime and carbon dioxide (CO_2). By the treatment of oil sands tailings with $Ca(OH)_2$ or with $Ca(OH)_2$ and CO_2 , the oil sands tailings become a non-segregating mix; i.e., the sand and the fines sediment and consolidate together. Also by the treatment of oil sands tailings with $Ca(OH)_2$ or with $Ca(OH)_2$ and CO_2 , the release water recovered from the settled and consolidated tailings would have acceptable water chemistry characteristics in terms of reduced concentrations of calcium ions (Ca^{2+}), magnesium ions (Mg^{2+}), sodium ions (Na^+), and chloride ions (Cl^-).

When the oil sand tailings are treated with $Ca(OH)_2$, the following ion exchange reaction takes place between the clay and the tailings pore water, which results in flocculation of the clay particles, mainly (but not necessarily only) by the following reaction:



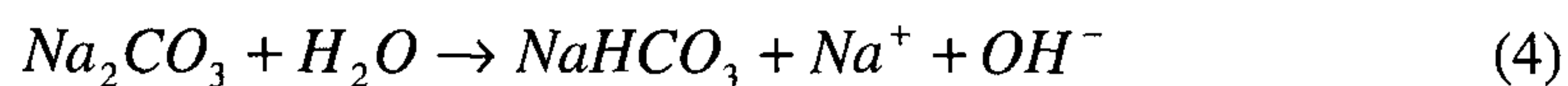
resulting in increase in the viscosity of the fines-water suspension, and the consequent formation of the yield stress which holds the sand particles in the fines-water suspension matrix and prevents the segregation of the sand particles. Treatment of oil sands tailings with $Ca(OH)_2$ also reduces the activity of the asphaltic acids in the aqueous solution because of the formation of the insoluble calcium salts of the asphaltic acids, which results in an increase in surface and interfacial tension of the water, which promotes the clay flocculation.

Both excess $Ca(OH)_2$ and sodium hydroxide ($NaOH$) produced by the reaction expressed in Equation (1) act as a base. As a result, the suspension and the release water pH are kept above 7 (pH being expressed as the minus of the logarithm of the hydrogen ions concentration $[H^+]$; i.e., $pH = -\log [H^+]$, a scale to express the acidity of the matter).

When the oil sand tailings are treated with $Ca(OH)_2$, the bicarbonate hardness caused mainly by the water-soluble calcium bicarbonate ($Ca(HCO_3)_2$) of the tailings is also reduced, by converting $Ca(HCO_3)_2$ into water-insoluble calcium carbonate ($CaCO_3$) by the following reactions:



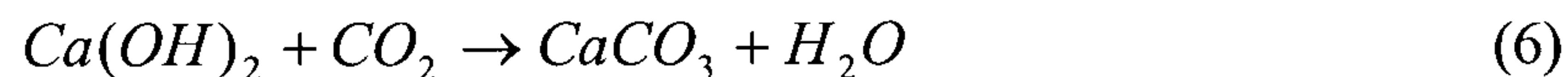
As an example, Ca^{2+} ions concentration in the release water recovered from the untreated tailings was at about 60 mg/L (milligram per liter), while Ca^{2+} ions concentration in the release water recovered from the tailings treated with $Ca(OH)_2$ was at about 30 mg/L. Sodium carbonate (Na_2CO_3) produced by the chemical reaction expressed by Equation (3) also promotes the basic nature of the suspension and the release water; for example, it helps the pH to be greater than 7 by the hydrolysis reaction:



When oil sands tailings are treated with $Ca(OH)_2$, the release water recovered from the tailings contains the excess $Ca(OH)_2$, $NaOH$, and Na_2CO_3 as a result of the chemical reactions expressed in Equations (1) and (3). If the release water is blended with the make-up water (e.g., river water, recycle water) or with any water with bicarbonate hardness for its use in the extraction process, the chemical species $Ca(OH)_2$, $NaOH$, and Na_2CO_3 contained in the release water reduces the bicarbonate hardness by the chemical reactions expressed in Equation (2), Equation (3) as well as by the following chemical reactions:



by which the water soluble $Ca(HCO_3)_2$ is converted to water insoluble $CaCO_3$. Also, because of the nature of the species produced by the chemical reactions expressed by Equations (1), (3), (4), and (5), the pH of the blended water would be basic; i.e., the pH of the blended water would be greater than 7. The pH of the blended water would be determined, however, by the dosage of $Ca(OH)_2$ treatment, the solids content, the fines content or fines-to-sand ratio (SFP), or more specifically the clay content of the tailings and the exposure of the water (release water, recycle water or blended water, or the tailings) to the atmospheric CO_2 , which could diffuse into the aqueous phase and acts as acid and reduces the pH by a reaction such as (but not limited to) the following:



When $Ca(OH)_2$ is used to treat oil sands tailings, the blended water (obtained from the blend of the release water with the make-up water, for its use in the extraction process) would have a pH higher than 7. Since the pH of the blended water is greater than 7, the bitumen extraction process would work better since the asphaltic acids contained in bitumen would be water soluble and would act as surfactants. Further, it would decrease surface tension and interfacial tension of the water, thus promoting clay dispersion and bitumen extraction efficiency. As a result, conditions favoring higher extraction efficiency by better dispersing the clays in the extraction process, however, would produce a tailings stream with difficult properties to handle since the fines and clay particles in the tailings would be more attractive to the water. This difficulty, however, could be overcome by treating the oil sands tailings with $Ca(OH)_2$ in the first place.

If needed, the excess amount of $Ca(OH)_2$ added into the oil sands tailings could be reduced by the controlled injection of CO_2 into tailings after treating the tailings with $Ca(OH)_2$ or by controlled injection of CO_2 into the release water. When CO_2 is injected in a controlled manner (i.e., by keeping the final pH of the tailings suspension or the release water preferably in the range of $11.0 < pH < 11.6$), the Ca^{2+} content in the aqueous media could be reduced to at about 30 mg/L range without causing any change in the segregating property of the tailings, by precipitating $Ca(OH)_2$ in the form of $CaCO_3$ by the chemical reaction expressed in Equation (6).

Uncontrolled or excessive injection of CO_2 into the tailings after treating it with $Ca(OH)_2$ or into the release water may cause the reduction of the pH in the range where water-soluble calcium bicarbonate would be formed by the following reaction:



which causes an increase in the Ca^{2+} ions concentration in the release water which could harm the bitumen extraction efficiency if the release water is recycled to the extraction plant. Also, the chemical reaction expressed in Equation (7) would cause segregation of the tailings.

It has been observed experimentally by the inventor that the injection of CO_2 into tailings appears to help flotation of the residual bitumen in the form of a water-in-oil emulsion.

Formation of the fresh $CaCO_3$ crystals in the tailings as a result of the chemical reactions expressed in Equations (2), (3), (5), and (6) would result in the adsorption of the ultra fines (i.e., clay particles smaller than $0.2\ \mu m$ size) on the surface of newly formed $CaCO_3$ crystal and precipitate them together with it, which results in reduction of the gel formation property of the tailings, since the ultra fines content of the tailings is partly responsible for the gel formation strength of the oil sands tailings. Also, the formation of the fresh $CaCO_3$ crystals in the tailings would result in the adsorption of Na^+ and Cl^- ions, on the surface of newly-formed $CaCO_3$ crystals and precipitate them together with it, which results in the reduction of the Na^+ and Cl^- ions in the release water recovered from the tailings. As an example, Na^+ ions concentration in the release water recovered from the untreated tailings was at about 130 mg/L, while Na^+ ions concentration in the release water recovered from the tailings treated with $Ca(OH)_2$ was at about 115 mg/L.

Similarly, formation of the fresh $CaCO_3$ crystals in the release water or any kind of blended water obtained by blending the release water with the make-up water, as a result of the chemical reactions expressed in Equations (2), (3), (5), and (6), would result in the adsorption of Na^+ and Cl^- ions, and even the organic compounds responsible for the coloration of the water, on the surface of newly-formed $CaCO_3$ crystal surface and precipitated together with it, which results in the reduction of the Na^+ and Cl^- ions, and even in the reduction of the coloration of the water.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying figures, in which numerical references denote like parts, and in which:

FIGURE 1 is a schematic flow chart of a method of treating oil sands tailings in accordance with a first embodiment of the present invention.

FIGURE 2 is a schematic flow chart of a method of treating oil sands tailings in accordance with a second embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Experiments performed by the inventor have indicated that treatment of oil sands tailings with $Ca(OH)_2$ improves the nonsegregating, settling and consolidation characteristics of the oil sands tailings. It is known that oil sands tailings have the tendency to become a nonsegregating mix as the solids content increases and as the fines content (i.e., fraction of the solids smaller than 325 mesh or 44 micron size) increases. Addition of Ca^{2+} ions into the oil sands tailings improves the nonsegregation behavior of the tailings; for example, it pushes the segregation boundary towards a lower solids content region.

It is important that segregation boundary lines (i.e., the lines of solids contents for various fines contents or SFRs, lower than which the tailings behave segregatingly, and higher than which the tailings behave non-segregatingly) for the tailings, both without any chemical additive and with different chemical additives, are parallel to the fixed fines-water ratio lines (the fines-water ratio being defined as the ratio of the fines/(fines + water) on mass basis), which is the indication that rheological characteristics of the fines-water suspension control the segregation behavior of the tailings. Addition of chemicals such as $Ca(OH)_2$ into the oil sands tailings changes the rheology of the fines-water suspension; i.e., forms sufficient yield stress and prevents segregation.

It is known that asphaltic acids present in oil sands bitumen become water soluble when the oil sands ore water suspension pH is kept slightly above 7. These asphaltic acids are partly aromatic in nature and contain oxygen functional groups of phenolic, carboxylic and sulphonic types. When the asphaltic acids become water soluble, they act as surfactants and reduce the surface and interfacial tension of the water (aqueous media); as a result, they act as clay dispersants and promote the liberation of bitumen, thus enhancing the bitumen recovery efficiency of the extraction process. The conditions favoring clay dispersion in extraction process also favor production of oil sands tailings with difficult settling and consolidation characteristics.

As stated earlier, presence of water-soluble asphaltic acids in the tailings promote the clay dispersion. Addition of small quantities of Ca^{2+} ions into the tailings reduces the activity of asphaltic acids in the aqueous phase. This results in an increase in surface and interfacial tension, which promotes the clay (and fines) flocculation, in addition to the mechanism of clay bonding by Ca^{2+} ions as explained by the chemical reaction expressed in Equation (1). Therefore, addition of a small quantity of Ca^{2+} ions into the tailings suspension by treating the tailings with $Ca(OH)_2$ would promote flocculation of clay and fines, and would promote the nonsegregating property of the tailings. Also, addition of small quantity of CaO , as small as 0.4 g/L CaO , into oil sands tailings increases the pH , which results in the precipitation of the Mg^{2+} ions in the form of $Mg(OH)_2$, therefore resulting in the production of a release water with Mg^{2+} concentration less than 1.8 mg/L. The Mg^{2+} concentration of the release water produced from oil sands tailings without $Ca(OH)_2$ treatment was about 24 mg/L.

Treatment of the tailings with $Ca(OH)_2$ provides additional advantages as discussed in the "Summary of the Invention" section of the present patent application. Treatment of oil sands tailings with $Ca(OH)_2$ reduces bicarbonate hardness in the tailings by converting $Ca(HCO_3)_2$ to $CaCO_3$. Also, Ca^{2+} ions in the release water caused by excessive dosage of $Ca(OH)_2$ could be reduced by controlled injection of CO_2 into tailings or by controlled injection of CO_2 into the release water. Furthermore, the release water could be treated, if needed, with soda ash (Na_2CO_3) which precipitates excess $Ca(OH)_2$ in form $CaCO_3$ by the following reaction:



Production of caustic soda ($NaOH$) by the ion exchange reactions between the clay and $Ca(OH)_2$ as explained by Equation (1) and by treating the release water containing excess $Ca(OH)_2$ with Na_2CO_3 as explained by Equation (8) are additional advantages of using $Ca(OH)_2$ for the treatment of oil sands tailings, because a valuable chemical $NaOH$, which costs about \$1,000 per ton, could be produced from CaO lime (when CaO is dissolved in water it forms $Ca(OH)_2$ by the chemical reaction, $CaO + H_2O \rightarrow Ca(OH)_2$), which costs about \$50 per ton and Na_2CO_3 which costs about \$100 per ton.

Precipitation of excess Ca^{2+} ions by the controlled injection of CO_2 into oil sands tailings after its treatment with $Ca(OH)_2$ provides another advantage. The ultra fine clay particles, cations and anions like Na^+ and Cl^- and organic molecules causing color in the water are adsorbed on the freshly formed surfaces of the $CaCO_3$ crystals and precipitated together with it, which results in faster water release rate and lower Na^+ ion concentration in the release water. Reduction of Na^+ in the release water would be another reason to use $Ca(OH)_2$ for the treatment of oils and tailings, since the accumulation of Na^+ in the recycle water over the years would have a detrimental effect on the extraction efficiency.

Based on the experimental evidence observed by the author of the present patent application, which are explained in "Summary of the Application" and "Description of the Preferred Embodiment" sections, oil sands tailings could be treated with CaO or with CaO and CO_2 to improve its settling, consolidation and segregation characteristics and to produce a release water with acceptable water chemistry properties for its use in the extraction process, in the followings methods or their minor modifications could be used:

First Embodiment of the Method

Figure 1 schematically illustrates a method of treating oil sands fines in accordance with a first embodiment of the invention. This method is suitable when the oil sands tailings discharged from the extraction plant are not of sufficiently high solids and fines contents to form a nonsegregating tailings even after treated with $Ca(OH)_2$.

In this case, oil sands tailings are passed through cyclones, producing cyclone underflow and cyclone overflow streams. Depending on the plant operating conditions, cyclone underflow may be at about above 60% solids with 3% fines (i.e., 3% of the solids smaller than 44 micron size) and cyclone overflow could be at about above 15 percent solids with 50% fines (i.e., 50% of the solids smaller than 44 micron size). Cyclone overflow will be thickened in a thickener with the help of preferably polymeric flocculent to about over 40% solids content (fines content of the thickened tailings would be the same provided that all of the fines are flocculated and settled, and that the thickener overflow would not contain any fines).

Then, the cyclone underflow and the thickener underflow will be blended at proper proportions and treated with $Ca(OH)_2$ to produce a nonsegregating mix for its final disposal. It is also possible to add existing mature fine tails (MFT, which is of about 33% solids and 98% fines, accumulated over the years as a result of the disposal of the hot water extraction process tailings) into the blend of cyclone underflow and thickener underflow, to improve the non-segregating characteristic of the tailings mix (although this may result in the reduction of settling and consolidation rates).

The dosage of $Ca(OH)_2$ treatment could be as low as, but not limited to, the equivalent of 400 g/m³ (grams per cubic meter of tailings) of CaO , which would be the sufficient $Ca(OH)_2$ dosage to produce a nonsegregating mix with acceptable settling and consolidation properties and to produce release water with acceptable water chemistry properties for its recycle to the extraction plant. The minimum dosage of $Ca(OH)_2$ required in this process would be a function of the solids content, fines content (or sand-to-fines ratio, SFR, the ratio of the masses of sand to fines), and the extent of clay dispersion. The release water produced in accordance with this first embodiment of the method will contain reduced amounts of Ca^{2+} , Mg^{2+} , Na^+ and Cl^- ions and lesser amount of ultra fines than the original tailings before the $Ca(OH)_2$ treatment.

The $Ca(OH)_2$ used for the treatment of the tailings would reduce the bicarbonate hardness of the tailings pore water. The remaining excess amount of the $Ca(OH)_2$ and the chemicals produced by the chemical reactions as a result of the $Ca(OH)_2$ treatment present in this release water could be used to reduce the bicarbonate hardness of the make-up water (which could be river water, recycle water, or water from any other suitable source). The thickener overflow, which is basically the process water recovered during the thickening of the cyclone overflow, could also be blended in any suitable proportions with the release water. A final water conditioning plant for the blended water (i.e., blend of the release water with fresh river water, thickener overflow, or water from another suitable source), by using CaO , CO_2 , Na_2CO_3 or another conventionally used water conditioning chemical, could be considered as an option.

As indicated in Figure 1, the oil sands tailings optionally may also be treated with CaO lime (or $\text{Ca}(\text{OH})_2$) depending on the needs of the plant operation, preferably but not limited to (i) by adding CaO into the tailings before the cyclones, (ii) by adding CaO after blending the Thickener Underflow and Cyclone Underflow and Mature Fines Tailings (MFT) as optional, (iii) by adding CaO into the tailings before the cyclone, in the thickener, and after blending the Thickener Underflow and Cyclone Underflow and Mature Fines Tailings (MFT) as optional, or by any combination of these steps. Addition of CaO into the tailings before the cyclone or in the thickener provides a process option for the thickening process in the thickener due to the combined effects of polymeric flocculent and calcium ions (Ca^{2+}) on the flocculation of clay size particles.

Second Embodiment of the Method

Figure 2 schematically illustrates a method of treating oil sands fines in accordance with a second embodiment of the invention. This method is suitable when the oil sands tailings discharged from the extraction plant are of sufficiently high solids and fines contents to form a non-segregating tailings after being treated with $\text{Ca}(\text{OH})_2$.

In this case, the tailings treatment plant would not need to have cyclones and thickeners. Oil sands tailings treated with $\text{Ca}(\text{OH})_2$ would be of nonsegregating and of sufficiently fast-settling and consolidation properties. It is also possible to add existing mature fine tails (MFT, which is of about 33% solids and 98% fines, accumulated over the years as a result of the disposal of the hot water extraction process tailings) into the tailings discharged from the extraction plant, which would improve the nonsegregating characteristic of the tailings mix (although this may result in the reduction of settling and consolidation rates). The release water produced in accordance with this second embodiment of the method will contain reduced amounts of Ca^{2+} , Mg^{2+} , Na^+ and Cl^- ions and lesser amount of ultra fines than the original tailings before the $\text{Ca}(\text{OH})_2$ treatment. The $\text{Ca}(\text{OH})_2$ used for the treatment of the tailings would reduce the bicarbonate hardness of the tailings pore water. The remaining excess amount of the $\text{Ca}(\text{OH})_2$ and the chemicals produced by the chemical reactions as a result of the $\text{Ca}(\text{OH})_2$ treatment present in this release water could be used to reduce the bicarbonate hardness of the make-up water which could be the river water, the

recycle water or water from any other suitable source. A final water conditioning plant for the blended water (i.e., blend of the release water with fresh river water, thickener overflow, or water from another suitable source) by using CaO , CO_2 , Na_2CO_3 or another conventionally used water conditioning chemical could be considered as an option.

Experimental studies performed by the inventor have indicated that the methods described herein could be used for the oil sands tailings produced by caustic or non-caustic, hot or cold water slurry-based extraction processes. The dosage of $Ca(OH)_2$ treatment would be a function of the solids content and the sand-to-fines ratio of the tailings, the extent of clay dispersion in the extraction process (which is strongly dependent upon the pH of the extraction process), and the composition of the make-up water to be blended with the release water produced from the tailings treated with $Ca(OH)_2$.

Persons skilled in the field of the invention will appreciate that the present invention provides a variety of advantages and benefits, including the following:

1. Production of substantially non-segregating tailings with acceptable settling, consolidation and water release rate properties, with simultaneous production of release water with acceptable water chemistry characteristics for use in the bitumen extraction process.
2. Production of release water with lower concentrations of Ca^{2+} , Mg^{2+} , Na^+ , Cl^- ions, ultra fines, and color-making organic species concentrations.
3. Release water with excess $Ca(OH)_2$ and other chemicals produced by treating the oil sands tailings with $Ca(OH)_2$ may be used for the conditioning of the make-up water.
4. Existing inventories of mature fine tails (MFT) may be reduced by adding the MFT into the blend of cyclone underflow and thickener underflow, or into the whole tailings discharged from the extraction plant, depending on the composition of the tailings produced by the extraction process.

5. Cost-effective management of oil sands tailings produced by any kind of water slurry-based bitumen extraction process.
6. The process of the invention is simple to use in commercial environments and uses low-cost chemicals for the management of oil sands tailings.
- 5 7. The process can be smoothly integrated into existing bitumen extraction and oil sands tailings management processes.

In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following that word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one such element.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A method for reducing segregation between sand and fines in oil sands tailings from
5 water slurry-based bitumen extraction processes, said method comprising:

(a) passing coarse oil sands tailings through a cyclone so as to produce:

a.1 a cyclone underflow stream having a solids content of at least 60
percent by weight, with approximately 3 percent of said solids being
fines; and

10 a.2 a cyclone overflow stream having a solids content of at least 15
percent by weight, with approximately 50 percent of said solids being
fines;

(b) passing the cyclone overflow stream through a thickener so as to produce a
thickener underflow having a solids content of at least 40 percent by weight;

15 (c) blending the cyclone underflow stream and the thickener underflow stream to
produce blended tailings;

(d) treating the blended tailings with calcium oxide at a dosage of at least 400
grams of calcium oxide per cubic meter of blended tailings; and

20 (e) injecting carbon dioxide into the blended tailings subsequent to treatment with
calcium oxide, with the dosage of carbon dioxide being controlled to maintain
the *pH* of the tailings within the range of 11.0 to 11.6.

2. The method of Claim 1 wherein the calcium oxide is introduced into the blended
tailings in the form of calcium hydroxide.

3. The method of Claim 1 or Claim 2 comprising the further step of adding calcium
25 oxide to the coarse oil sands tailings upstream of the cyclone.

4. The method of any one of Claims 1-3 comprising the further step of mixing a
polymeric flocculent with the cyclone overflow during the step of passing the cyclone
overflow stream through a thickener.

5. The method of any one of Claims 1-4 comprising the further step of adding calcium oxide to the cyclone overflow during the step of passing the cyclone overflow stream through a thickener.

6. The method of any one of Claims 1-5 comprising the further step of mixing mature fine tails with the blended tailings prior to treatment of the blended tailings with calcium oxide.

7. The method of any one of Claims 1-6 comprising the further step of mixing mature fine tails with the blended tailings during treatment of the blended tailings with calcium oxide.

8. A method for reducing segregation between sand and fines in oil sands tailings from water slurry-based bitumen extraction processes, said method comprising:

(a) treating the oil sands tailings with calcium oxide at a dosage of at least 400 grams of calcium oxide per cubic meter of tailings; and

(b) injecting carbon dioxide into the oil sands tailings subsequent to treatment with calcium oxide, with the dosage of carbon dioxide being controlled to maintain the *pH* of the tailings within the range of 11.0 to 11.6.

9. The method of Claim 8 wherein the calcium oxide is introduced into the oil sands tailings in the form of calcium hydroxide.

10. The method of Claim 8 or Claim 9 comprising the further step of mixing mature fine tails with the oil sands tailings prior to the step of treating of the oil sands tailings with calcium oxide.

11. The method of any one of Claims 8-10 comprising the further step of mixing mature fine tails with the oil sands tailings during the step of treating of the oil sands tailings with calcium oxide.

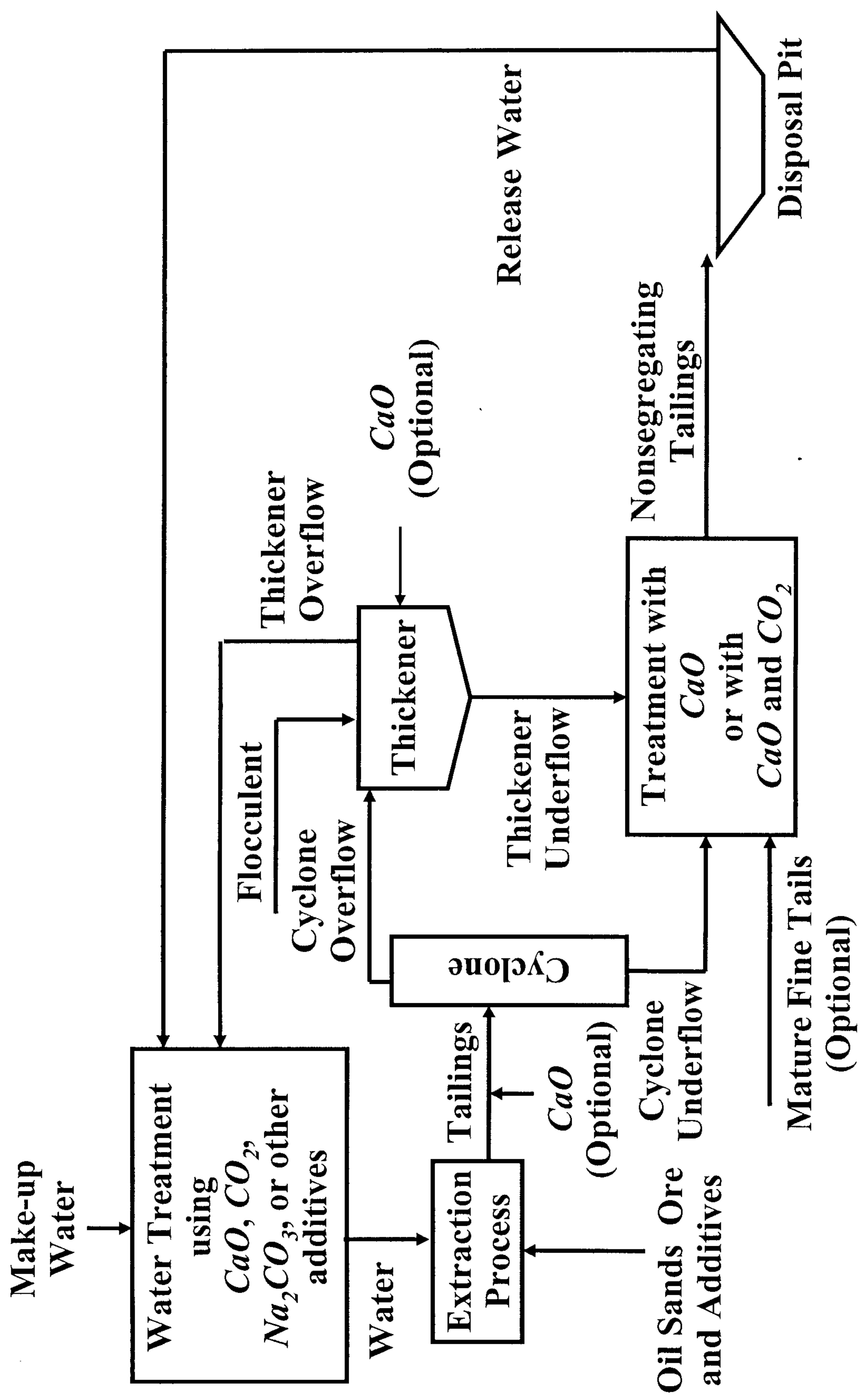


FIG. 1

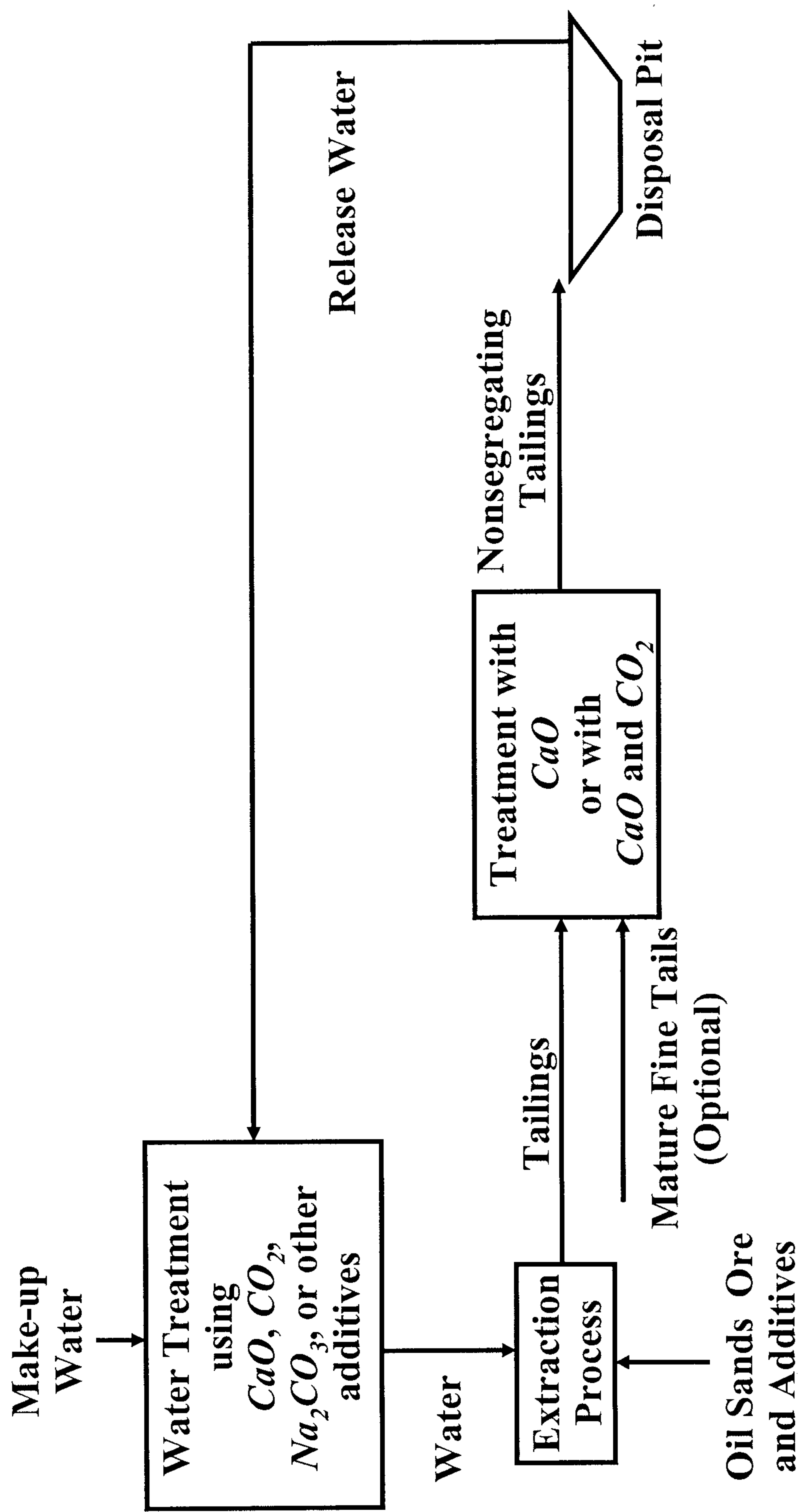


FIG. 2

