



(43) International Publication Date
2 October 2014 (02.10.2014)

- (51) International Patent Classification:
B01D 21/01 (2006.01) *B01D 37/03* (2006.01)
- (21) International Application Number:
PCT/US2014/015459
- (22) International Filing Date:
9 February 2014 (09.02.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
13/798,482 13 March 2013 (13.03.2013) US
- (71) Applicant: **ECOLAB USA INC.** [US/US]; 370 N. Wabasha Street, St. Paul, Minnesota 55102 (US).
- (72) Inventor: **URBANI, Carl N.**; 22 Ilex Way, Forrestfield, Western Australia 6058 (AU).
- (74) Agent: **SORENSEN, Andrew D.**; Ecolab Usa Inc., 655 Lone Oak Drive, Eagan, Minnesota 55121 (US).
- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*

(54) Title: IN-LINE TAILINGS TREATMENT PROCESS

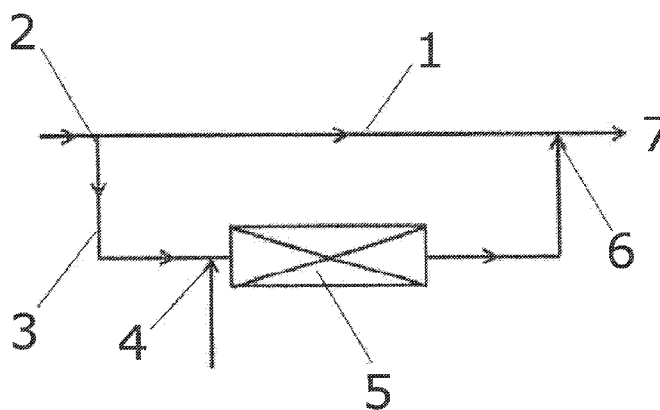


FIGURE 1

(57) **Abstract:** The invention is directed towards methods and compositions for improving the processing of mineral tailings. The method involves diverting a side stream from the main line of a tailings process flow. Into this side stream an additive such as a neat polymer without dilution is added and mixed and is then returned into the main line. By doing this only a portion of the overall tailings flow needs to undergo mixing yet the additive effectively treats the tailings. Even better the process avoids the need to add water to first invert and dilute the polymer additive. As a result tailings can be processed without incurring unnecessary mixing costs and unnecessary water addition.



IN-LINE TAILINGS TREATMENT PROCESS

Background of the Invention

The present invention relates generally to one or more methods,
5 compositions of matter, and or apparatuses useful in treating mineral slurries.
Mineral slurries such as tailings and other waste material have become a technical,
environmental and public policy issue. Mineral extraction and refining processes
including but not limited to those for coal, oil, iron, aluminum, copper, metals,
precious metals, zinc, lead, mineral sands and rare earth metals, often produce a
10 huge quantity of waste material known as tailings. Tailings are often in the form of
aggregate slurries which can be in aqueous suspension with dispersed particulate
solids, for instance sand, clay, shale and other minerals. It has been and still is a
sizable issue for industry to treat these tailings and accomplish liquid solid
separation at the processes end to separate liquid from the solid. This drastically
15 reduces the mass of the tailings and makes the disposal and/or recycling of tailings,
easier, safer, and more environmentally friendly.

A number of approaches have been developed to facilitate the
handling and disposal of tailings. US Patents 6,544,425 and 5,449,464, and US
Published Patent Applications 2011/0135797, 2010/0187181, 2008/0190860,
20 2011/0131873, 2011/0000854, and 2009/0020458 describe a number of previously
contemplated approaches. As described in US Patents 6,485,651, 5,788,867, and
7,901,583, a particularly effective approach involves the addition of synthetic or
natural polymers such as coagulants and flocculants to separate the solids from the
liquid. In addition, as described in US Published Patent Application 2012/0138542,
25 a particularly effective method for introducing chemicals into slurry is to do so using

an in-line introduction method. An ideal method of processing tailings however would make better use of chemical additives by optimal in-line addition of the additives in a highly efficient manner.

As a result there is ongoing need and clear utility in a novel improved
5 method and/or composition and/or apparatus for in-line treatment of a tailings process stream. The art described in this section is not intended to constitute an admission that any patent, publication or other information referred to herein is "Prior Art" with respect to this invention, unless specifically designated as such. In addition, this section should not be construed to mean that a search has been made or
10 that no other pertinent information as defined in 37 CFR § 1.56(a) exists.

Brief Summary of the Invention

At least one embodiment of the invention is directed towards a method for improving inline mineral slurries treatment. The method comprises
15 successively: providing an in-line flow of slurries in a main line stream; diverting a portion of the flow from the main line stream into a side stream flow; introducing at least one additive into the side stream flow through at least one injection point to cause dispersion of the additive and to start consolidation of the solids within the slurries to produce treated slurries; passing the side stream flow into a mixing
20 device; reintroducing the side stream flow into the main line; and transferring at least a portion of the main flow line into a deposit area.

The mineral slurry may comprise mineral tailings slurry derived from one or more of gold ore, platinum ore, nickel ore, coal ore, copper ore, iron ore, metal ore, ore-body from a diamond mine, or phosphate or gold tailings, red mud

from the Bayer alumina process, tailings resulting from oil sands extraction, tailings from lead ore, zinc ore or mineral sands processing and Mature Fine Tailings. The mixing device may be a static mixer. The amount of water introduced to the main line stream from the side stream flow may be no greater than the amount of water

5 diverted into the side stream flow plus the amount of water present in a neat form of the additive. The additive may be an oil in water emulsion, water in oil emulsion or solid polymer which is introduced in neat form. The additive may be introduced into the side stream flow by dosing the side stream slurry flow with an effective amount of additive, allowing the mixer to induce sufficient shear to and for a

10 sufficient time to invert and release the polymer into the side stream flow. The additive may be a quick inverting polymer which is introduced in neat form. The additive may be introduced into the side stream flow by dosing the side stream flow slurry with an effective amount of least one water-in-oil emulsion comprising at least one polymer, at least one hydrophilic surfactant and at least one high terpene

15 content natural oil, said surfactant being present in the emulsion at a concentration of from about 1 to about 10 percent, by weight; allowing the mixer to induce sufficient shear to and for a sufficient time for the at least one emulsion to invert and release the at least one polymer into the side stream flow. The net flow rate of the main line flow may be the same as the net flow rate of the side stream flow but the

20 rate of the side stream flow upstream and downstream from the mixing device differs from the net flow rate of the main line flow. The degree of respective consolidation and water release of the treated slurry may be greater than if a greater dosage of the additive were added directly into the main line flow. Between 0.1-50% of the slurry in the main line flow may be diverted into the side stream flow.

The method may further comprise the step of effecting a solid-liquid separation after the side stream flow has been reintroduced to the main line flow.

Brief Description of the Drawings

5 A detailed description of the invention is hereafter described with specific reference being made to the drawings in which:

FIG. 1 is an illustration of a process stream utilizing the invention.

For the purposes of this disclosure, like reference numerals in the figures shall refer to like features unless otherwise indicated. The drawings are only
10 an exemplification of the principles of the invention and are not intended to limit the invention to the particular embodiments illustrated.

Detailed Description of the Invention

The following definitions are provided to determine how terms used
15 in this application, and in particular how the claims, are to be construed. The organization of the definitions is for convenience only and is not intended to limit any of the definitions to any particular category.

"Consolidate" means a process in which the solid particles of a slurry, aggregate together to form high solids density regions which conversely
20 results in low solids density regions within the slurry, it can result in separation of the solid materials from the liquid phase of the slurry, types of consolidation include but are not limited to coagulation and/or flocculation.

"In-Line" means introduced into slurry flowing through a process stream.

"**Slurry**" means a mixture of solid particles suspended within a liquid carrier.

"**Neat** " means a composition of matter in the form in which it is typically stored or transported and which is different than the form in which it is typically applied to effect a chemical result, in the case of compositions which operate in aqueous environments such as polymers, "Neat" can mean in the form of an a oil-in water emulsion which is too concentrated and contains too little water to invert into a water-in oil emulsion. Alternatively it may mean a solid polymer.

"**Tailings**" means masses of waste material resulting from a mineral extraction or refining operation, tailings can be solid and/or slurry.

In the event that the above definitions or a description stated elsewhere in this application is inconsistent with a meaning (explicit or implicit) which is commonly used, in a dictionary, or stated in a source incorporated by reference into this application, the application and the claim terms in particular are understood to be construed according to the definition or description in this application, and not according to the common definition, dictionary definition, or the definition that was incorporated by reference. In light of the above, in the event that a term can only be understood if it is construed by a dictionary, if the term is defined by the *Kirk-Othmer Encyclopedia of Chemical Technology*, 5th Edition, (2005), (Published by Wiley, John & Sons, Inc.) this definition shall control how the term is to be defined in the claims.

Referring now to FIG. 1 there is shown at least one embodiment of the invention. A process stream comprising a flow of slurry is passing through a main line flow path (1). At a diversion point (2) in the main line flow path a portion

of the flowing slurry comprising between 0.1-50% of the overall flow is diverted into a side stream flow path (3). Within the side stream flow path (3) at least one processing additive is added to the slurry at an addition point (4). The slurry and the processing additive are suitably mixed together. This mixing can optionally be
5 accomplished by passing the two into a mixing apparatus (5) including but not limited to a static mixer. At a junction point (6) the mixed side stream flow is then rejoined to the main line flow path (1). The main line flow path (1) may then undergo further processing or be discharged into a waste pond or receptacle (7).

In at least one embodiment one or more side streams are diverted
10 from the main line at one or more locations along the main line. In at least one embodiment one or more side streams are re-introduced into the main line at one or more junction points along the main line. In at least one embodiment more than one side stream is diverted from the main line and at least one portion of the treatment the side streams undergoes (one or more of additive type, additive dosage, additive
15 concentration, mixing speed, mixing time, mixer type, and flow rate) differs or is the same.

In at least one embodiment the flow rates through a side stream and through the main line are the same or different. In at least one embodiment the net flow rate of the side stream and the main line are the same such that the flow rate
20 before and/or after the mixing step in the side stream is faster than that in the main line to compensate for the side stream residing in the mixer for a period of time. In at least one embodiment the flow rate in the main line or the side stream may be between 0.01 m³/h and 10,000 m³/h.

In at least one embodiment the processing additive comprises a composition of matter including but not limited to one or more of those described in US Patent 6,485,651. As described in US Patents 3,734,873 and 5,679,740, many processing additives are stored and transported in the form of an oil-in water
5 emulsion. In this form however the active portions of the composition cannot effectively interact with the contents of an aqueous medium. As a result when they are to affect the slurry the composition needs to have been inverted into a water-in oil type emulsion.

In prior art methods, when inverted compositions such as polymers
10 are added to a slurry stream they first pass through an inversion rig within which the additive undergoes mixing for a time with added water so neat composition inverts into a water-in oil emulsion. Only after being inverted is the additive then added to the slurry. In contrast in at least one embodiment neat and/or non-inverted additive is added directly into the side stream without previously undergoing inversion.

15 This method is the exact opposite of what is taught by the prior art which teaches that not only must all of the stream be mixed, but that some of the stream must be repeatedly mixed to properly effect the slurry with the additive. For example, in US Published Patent Application 2012/0138542, a slurry stream undergoes mixing and then a slip stream of the already mixed stream is re-fed into
20 the to-be mixed stream. In contrast to this, in the inventive method at least a portion of the stream never passes through a mixer yet as the Examples below demonstrate, superior results are observed. In at least one embodiment the addition of the additive is accomplished without the addition of any water other than that present in the neat form of the polymer. This is quite different than prior art methods which

typically require the addition of water in excess of that in the neat formulation to invert the additive. As a result the end slurry after treatment contains far less water and is less voluminous, less costly and is easier to dispose of.

In at least one embodiment the processing additive comprises a
5 polymer such as any type of water-soluble or water swell-able polymer, including natural, semi-natural and synthetic polymers. The polymers may include a wide variety of organic polymers which need to be selected depending for example of the nature of the tailings, their solids concentration, and other parameters well-known by the skilled man of the art. The natural polymers may be for instance
10 polysaccharides such as dextran, starch or guar gum. The semi-natural polymer may be carboxymethyl cellulose. Synthetic polymers may be a coagulant and/or a flocculant. Particularly suitable water soluble or water swellable polymers are based on acrylamide. They can be cationic, anionic, non-ionic or amphoteric polymer.

The polymer can be made by the polymerisation of: a) one or more
15 non-ionic monomer selected from the group comprising (meth)acrylamide, (meth)acrylic, vinyl, allyl or maleic backbone and having a polar non-ionic side group: mention can be made in particular, and without this being limitation, of acrylamide, methacrylamide, N-vinyl pyrrolidone, N-vinyl formamide, N,N dimethylacrylamide, N-vinyl acetamide, N-vinylpyridine, N-vinylimidazole,
20 isopropyl acrylamide and polyethelene glycol methacrylate and/or b) one or more anionic monomer(s) comprising (meth)acrylic, vinyl, allyl or maleic backbone, mention can be made in particular, and without this being limitation, of monomers having a carboxylic function (e.g.: acrylic acid, methacrylic acid and salts thereof), or having a sulphonic acid function (e.g.: 2-acrylamido-2-methylpropane sulphonic

acid (ATBS) and salts thereof) and/or c) one or more cationic monomer(s) comprising (meth)acrylamide, (meth)acrylic, vinyl, allyl or maleic backbone and having an amine or quaternary ammonium function, mention can be made in particular, and without this being limitation, of quaternized or salified

5 dimethylaminoethyl acrylate (ADAME) and/or dimethylaminoethyl methacrylate (MADAME); dimethyldiallylammonium chloride (DADMAC), acrylamido propyltrimethyl ammonium chloride (APTAC) and/or methacrylamido propyltrimethyl ammonium chloride (MAPTAC).

The polymer may contain one or more monomers having a

10 hydrophobic character. Hydrophobic monomers are preferably selected from the group including (meth)acrylic acid esters with an alkyl, arylalkyl and/or ethoxylated chain, derivatives of (met)acrylamide with an alkyl, arylalkyl or dialkyl chain, cationic allyl derivatives, anionic or cationic hydrophobic (meth)acryloyl derivatives, or anionic and/or cationic monomers derivatives of (meth)acrylamide bearing a hydrophobic

15 chain. Anionic polymers may be formed from monomers selected from ethylenically unsaturated carboxylic acid and sulfonic acid monomers, preferably selected from (meth) acrylic acid and/or 2-Acrylamido-2-methylpropane sulfonic acid, and their salts, combined with non-ionic co-monomers, preferably selected from (meth) acrylamide, N-vinyl pyrrolidone.

20 The polymer may be linear, branched or crosslinked. Branching or crosslinking agents are selected from the group comprising methylene bisacrylamide (MBA), ethylene glycol diacrylate, polyethylene glycol dimethacrylate, diacrylamide, cyanomethylacrylate, vinyloxyethylacrylate or methacrylate, triallylamine, formaldehyde, glyoxal, compounds of the glycidylether type such as

ethyleneglycol diglycidylether, or epoxy.

The dosage of the polymer added in the in-line flow may be between 50 and 5,000 g per ton of dry solids of mineral slurries, preferably between 250 and 2,000 g/t, and more preferably between 500 and 1,500 g/t, depending on the nature
5 and the composition of the tailings to be treated.

The process of the invention is suitable for treating aqueous mineral slurries of particulate solids. Mineral slurries result from the processing of minerals which includes ore beneficiation and the extraction of minerals. Minerals broadly include ores, natural substances, inorganics, mixtures of inorganic substances and
10 organic derivatives such as coal.

The slurry may contain tailings of suspended particulate solids. Typical slurries include but are not limited to aqueous tailings or mineral slurries obtained from a gold ore, platinum ore, nickel ore, coal ore, copper ore, or an ore-body from a diamond mine, or phosphate or gold tailings, red mud from the Bayer
15 alumina process, tailings resulting from oil sands extraction, and Mature Fine Tailings (MFT) which are specific because of the large proportion of fine solid particles, less than 44 microns. MFT are difficult to dewater and to solidify.

Without being limited by a particular theory or design of the invention or of the scope afforded in construing the claims, it is believed that the
20 method is able to take advantage of the kinetic energy inherent in the process stream to effectively disperse and invert the additives and thereby consolidate the solids contained in the tailings slurry without directly mixing all of the flowing slurry with the additives. This drastically reduces the capital costs associated with processing tailings slurry.

EXAMPLES

The foregoing may be better understood by reference to the following examples, which are presented for purposes of illustration and are not intended to
5 limit the scope of the invention.

Laboratory testing was conducted on 4 samples of coal tailings slurry.

Example 1: A side stream was simulated by taking a sample of 100 ml of coal tailings slurry comprising 16% solids which was stirred using a cage stirrer at
10 800 rpm. An acrylamide/acrylate latex polymer was added to the mixture and the resulting slurry was stirred for 5 minutes. A 0.2 ml aliquot of this mixed slurry was added to 200 ml of untreated coal tailings slurry in a 400 ml cup which simulated return of the side stream to the main line. Further passage of the main line was simulated by pouring the cups contents into another cup 5 times. At this point all
15 the solids in the cup had consolidated and settled leaving clear water visible in the cup. The dose of the polymer was equivalent to 280 g/T. In contrast when the same polymer dose was directly added to a separate slurry sample in another 200 ml cup and similarly repeatedly poured, no consolidation or water release was observed.

Example 2: A side stream was simulated by taking a sample of 100 ml of
20 coal tailings slurry comprising 22.5% solids which was stirred using a cage stirrer at 800 rpm. An acrylamide/acrylate latex polymer was added to the mixture and the resulting slurry was stirred for 5 minutes. A 0.5 ml aliquot of this mixed slurry was added to 200 ml of untreated coal tailings slurry in a 400 ml cup which simulated return of the side stream to the main line. Further passage of the main line was

simulated by pouring the cups contents into another cup 7 times. A second 0.5 ml aliquot was added to the cup and re-poured 4 more times. At this point the solids in the cup had consolidated and settled leaving clear water visible in the cup. The overall dose of the polymer was equivalent to 660 g/T. In contrast when this same dosage of polymer was directly added to a separate slurry sample in another 400 ml cup and similarly repeatedly poured, no consolidation or water release was observed.

Example 3: A side stream was simulated by taking a sample of 100 ml of coal tailings slurry comprising 29% solids which was stirred using a cage stirrer at 800 rpm. An acrylamide/acrylate latex polymer was added to the mixture and the resulting slurry was stirred for 5 minutes. A 1.0 ml aliquot of this mixed slurry was added to 100 ml of untreated coal tailings slurry in a 400 ml cup which simulated return of the side stream to the main line. Further passage of the main line was simulated by pouring the cups contents into another cup 20 times. A second 0.5 ml aliquot was added to the cup and re-poured 30 more times. At this point the solids in the cup had consolidated and settled leaving clear water visible in the cup. The dose of the polymer was equivalent to 1530 g/T. In contrast when the polymer at this dosage was directly added to a separate sample in another 400 ml cup and similarly repeatedly poured, no consolidation or water release was observed.

Example 4: A side stream was simulated by taking a sample of 100 ml of coal tailings slurry comprising 16% solids which was stirred using a cage stirrer at 800 rpm. An acrylamide/acrylate latex polymer (which was different from the polymer used in Example 1) was added to the mixture and the resulting slurry was stirred for 5 minutes. A 0.3 ml aliquot of this mixed slurry was added to 200 ml of

untreated coal tailings slurry in a 400 ml cup which simulated return of the side stream to the main line. Further passage of the main line was simulated by pouring the cups contents into another cup 20 times. A second 0.2 ml aliquot was added to the cup and re-poured 20 more times. At this point the solids in the cup had

5 consolidated and settled leaving clear water visible in the cup. The dose of the polymer was equivalent to 470 g/T. In contrast when the same polymer at this dosage was directly added to a separate slurry sample in another 200 ml cup and similarly repeatedly poured, no consolidation or water release was observed.

These examples demonstrate that reintroducing a mixed side stream

10 into a main line causes a different effect than directly introducing that same product into the main line and mixing.

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. The present disclosure is an exemplification of the principles of the invention and is not

15 intended to limit the invention to the particular embodiments illustrated. All patents, patent applications, scientific papers, and any other referenced materials mentioned herein are incorporated by reference in their entirety. Furthermore, the invention encompasses any possible combination of some or all of the various embodiments described herein and/or incorporated herein. In addition the invention encompasses

20 any possible combination that also specifically excludes any one or more of the various embodiments described herein and/or incorporated herein.

The above disclosure is intended to be illustrative and not exhaustive. This description will suggest many variations and alternatives to one of ordinary skill in this art. The compositions and methods disclosed herein may comprise,

consist of, or consist essentially of the listed components, or steps. As used herein the term "comprising" means "including, but not limited to". As used herein the term "consisting essentially of" refers to a composition or method that includes the disclosed components or steps, and any other components or steps that do not

5 materially affect the novel and basic characteristics of the compositions or methods. For example, compositions that consist essentially of listed ingredients do not contain additional ingredients that would affect the properties of those compositions. Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be

10 encompassed by the claims.

All ranges and parameters disclosed herein are understood to encompass any and all subranges subsumed therein, and every number between the endpoints. For example, a stated range of "1 to 10" should be considered to include any and all subranges between (and inclusive of) the minimum value of 1 and the

15 maximum value of 10; that is, all subranges beginning with a minimum value of 1 or more, (e.g. 1 to 6.1), and ending with a maximum value of 10 or less, (e.g. 2.3 to 9.4, 3 to 8, 4 to 7), and finally to each number 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 contained within the range.

All numeric values are herein assumed to be modified by the term

20 "about," whether or not explicitly indicated. The term "about" generally refers to a range of numbers that one of skill in the art would consider equivalent to the recited value (i.e., having the same function or result). In many instances, the term "about" may include numbers that are rounded to the nearest significant figure. Weight percent, percent by weight, % by weight, wt %, and the like are synonyms that refer

to the concentration of a substance as the weight of that substance divided by the weight of the composition and multiplied by 100. Percentages and ratios are by weight unless otherwise so stated.

As used in this specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a composition containing “a compound” includes a mixture of two or more compounds. As used in this specification and the appended claims, the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise. All chemical structures provided in this application contemplate and include every possible stereo isomers, conformational isomers, rotational isomers, and chiral alternative of the specific illustrated structure.

This completes the description of the preferred and alternate embodiments of the invention. Those skilled in the art may recognize other equivalents to the specific embodiment described herein which equivalents are intended to be encompassed by the claims attached hereto.

Claims

What is claimed is:

1. A method for improving inline mineral slurries treatment comprising successively: providing an in-line flow of slurries in a main line stream; diverting a
5 portion of the flow from the main line stream into a side stream flow; introducing at least one additive into the side stream flow through at least one injection point to cause dispersion of the additive and to start consolidation of the solids within the slurries to produce treated slurries; passing the side stream flow into a mixing device; reintroducing the side stream flow into the main line; and transferring at
10 least a portion of the main flow line into a deposit area.
2. The method of claim 1 in which the mineral slurry comprises mineral tailings slurry derived from one or more of gold ore, platinum ore, nickel ore, coal ore, copper ore, iron ore, metal ore, ore-body from a diamond mine, or phosphate or gold
15 tailings, red mud from the Bayer alumina process, tailings resulting from oil sands extraction, tailings resulting from zinc ore, lead ore or mineral sands processing and Mature Fine Tailings.
3. The method of claim 1 in which the mixing device is a static mixer.
4. The method of claim 1 in which the amount of water introduced to the main
20 line stream from the side stream flow is no greater than the amount of water diverted into the side stream flow plus the amount of water present in a neat form of the additive.
5. The method of claim 1 in which the additive is an oil in water emulsion, water in oil emulsion or solid polymer which is introduced in neat form.

6. The method of claim 5 in which the additive is introduced into the side stream flow by dosing the side stream slurry flow with an effective amount of additive, allowing the mixer to induce sufficient shear to and for a sufficient time to invert and release the polymer into the side stream flow.
- 5 7. The method of claim 1 in which the additive is a quick inverting polymer which is introduced in neat form.
8. The method of claim 7 in which the additive is introduced into the side stream flow by dosing the side stream flow slurry with an effective amount of least one water-in-oil emulsion comprising at least one polymer, at least one hydrophilic
10 surfactant and at least one high terpene content natural oil, said surfactant being present in the emulsion at a concentration of from about 1 to about 10 percent, by weight; allowing the mixer to induce sufficient shear to and for a sufficient time for the at least one emulsion to invert and release the at least one polymer into the side stream flow.
- 15 9. The method of claim 1 in which the net flow rate of the main line flow is the same as the net flow rate of the side stream flow but the rate of the side stream flow upstream and downstream from the mixing device differs from the net flow rate of the main line flow.
10. The method of claim 1 in which the degree of respective consolidation and
20 water release of the treated slurry is greater than if a greater dosage of the additive were added directly into the main line flow.
11. The method of claim 1 in which between 0.1-50% of the slurry in the main line flow is diverted into the side stream flow.

12. The method of claim 1 further comprising the step of effecting a solid-liquid separation after the side stream flow has been reintroduced to the main line flow.

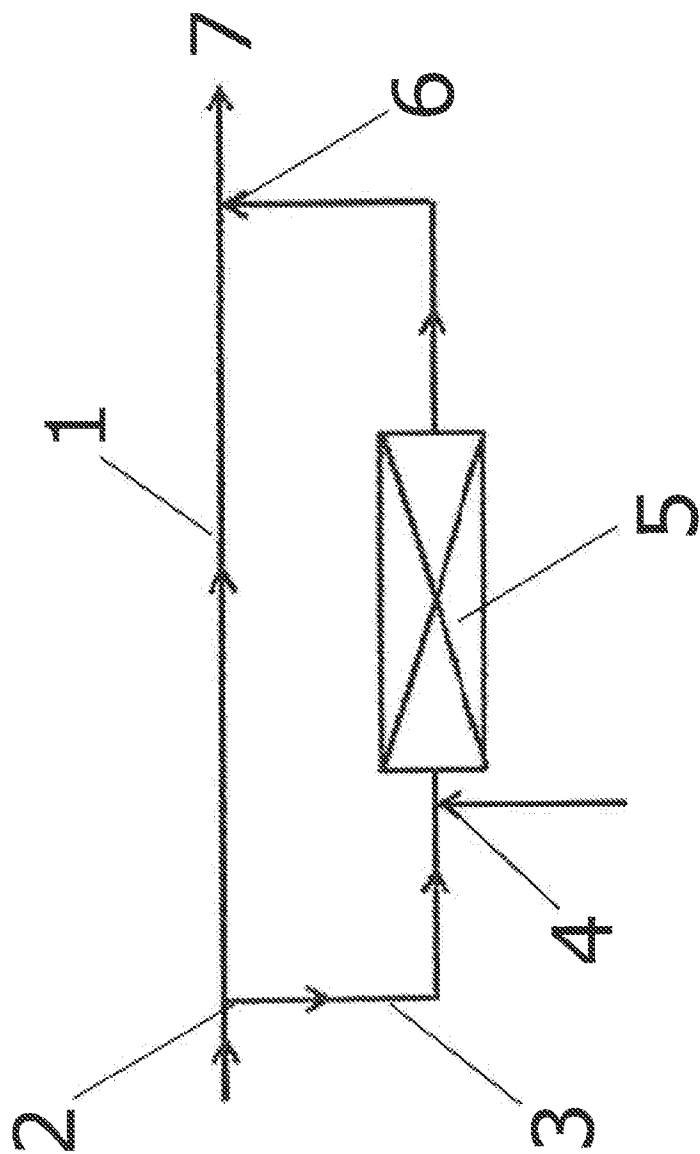


FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/015459**A. CLASSIFICATION OF SUBJECT MATTER****B01D 21/01(2006.01)i, B01D 37/03(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)

B01D 21/01; C01F 7/06; C02F 1/52; C22B 58/00; C01F 3/00; B01D 37/03

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: inline, mineral slurries treatment, additive, mixer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012-0138542 A1 (DANG-VU, TRONG et al.) 07 June 2012 See paragraphs [0052]-[0055]; claims 1 and 3; figures 1-2.	1-12
A	US 3856668 A (SHUBERT, R.) 24 December 1974 See column 5, lines 5-61; claim 1; figure 1.	1-12
A	WO 93-13017 A1 (ALCAN INTERNATIONAL LIMITED) 08 July 1993 See claims 1 and 12.	1-12
A	US 2006-0191853 A1 (BALLENTINE, FRANKLYN A. et al.) 31 August 2006 See claims 1 and 6.	1-12
A	US 2005-0109702 A1 (DWYER, PATRICK J.) 26 May 2005 See claim 1.	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

02 May 2014 (02.05.2014)

Date of mailing of the international search report

07 May 2014 (07.05.2014)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

KIM, Seung Beom

Telephone No. +82-42-481-3371



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/015459

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012-0138542 A1	07/06/2012	None	
US 3856668 A	24/12/1974	None	
WO 93-13017 A1	08/07/1993	AU 1993-55093 A	28/07/1993
		AU 661085 B2	13/07/1995
		BR 9206989 A	15/02/2000
		CA 2124570 A1	08/07/1993
		DE 69215536 D1	09/01/1997
		DE 69215536 T2	27/03/1997
		EP 0618882 A1	12/10/1994
		EP 0618882 B1	27/11/1996
		ES 2095035 T3	01/02/1997
		JP 02658771 B2	30/09/1997
		JP 05-229816 A	07/09/1993
US 2006-0191853 A1	31/08/2006	AU 2006-219036 A1	08/09/2006
		AU 219036 B2	23/12/2010
		BR PI0609046 A2	16/11/2010
		CA 2598848 A1	08/09/2006
		CN 101128244 A	20/02/2008
		CN 101128244 B	29/09/2010
		CN 101658736 A	03/03/2010
		EP 1850938 A1	07/11/2007
		JP 2008-531256 A	14/08/2008
		RU 2007135349 A	27/03/2009
		RU 2415694 C2	10/04/2011
		US 2011-0150754 A1	23/06/2011
		US 8216534 B2	10/07/2012
		WO 2006-093588 A1	08/09/2006
US 2005-0109702 A1	26/05/2005	AP 200603604 D0	30/04/2006
		AU 2005-294696 A1	16/06/2005
		BR PI0416825 A2	10/03/2009
		CA 2546112 A1	16/06/2005
		EA 200600887 A1	27/10/2006
		EP 1689530 A1	16/08/2006
		JP 2007-512124 A	17/05/2007
		MX PA06005664 A	14/12/2006
		US 7244361 B2	17/07/2007
		WO 2005-053853 A1	16/06/2005