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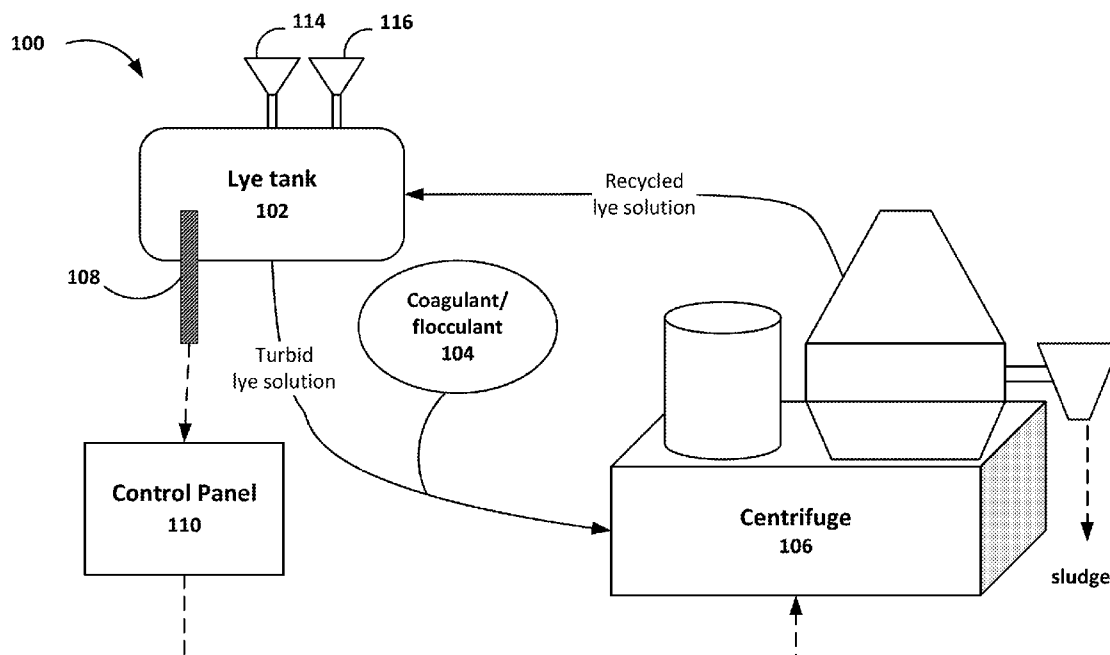


FIG. 1

(57) Abstract: A method for separating solid waste from a washing solution includes collecting the washing solution from an industrial process and separating the solid waste from the washing solution using a centrifuge. The washing solution includes hydroxide and other washing additives. A system for recycling washing solutions includes a tank (102) for the washing solution in fluid communication with a centrifuge (106). The centrifuge removes solid waste and returns the washing solution to the tank. Hydroxide and other washing additives in solution can be reused more times when there is less solid waste suspended in the solution.

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RECYCLING WASHING SOLUTIONS

TECHNICAL FIELD

[1] The present disclosure relates generally to methods and compositions for recycling washing solutions used in industrial processes.

BACKGROUND

[2] Alkali metal hydroxides (also known as lye or hydroxide) are used in many industrial cleaning processes. In one example, alkali metal hydroxide is used in the bottle washing process for the beverage industry. The bottles are typically glass but could also be reusable polyethylene terephthalate (PET). During this process, a bottle washing aid is added to a 2-5% alkali metal hydroxide solution in cleaning tanks of a bottle washing machine. Dirty beverage bottles are passed through the cleaning tanks containing alkali metal hydroxide and then are rinsed in water tanks. Over time, the soil concentration in the cleaning tanks increases, thereby reducing the bottle washing capability of the lye. As a result, disposal or renewal of the alkali metal hydroxide solution is required periodically. In other words, additional cleaning chemicals can be added to the cleaning tanks as the efficacy of the alkali metal hydroxide declines. Alternatively, the spent alkali metal hydroxide solution can be removed and replaced with new alkali metal hydroxide solution.

[3] Typically, the alkali metal hydroxide is not recycled or recovered in the bottle washing process. This results in large quantities of alkali metal hydroxide being wasted. Additionally, additional chemicals are required to treat and neutralize the hydroxide solution before disposal. This places additional burden on the wastewater system to treat the used alkali metal hydroxide solution and to discharge the alkali metal hydroxide solution into the environment after it has been treated. The discharge of alkali metal hydroxide stresses the environment due to the pH fluctuation and high chemical oxygen demand (COD) created from the alkali metal hydroxide waste stream. The COD of waste alkali metal hydroxide is about 5000 to 10000 parts per million (ppm).

[4] In the instances in which alkali metal hydroxide is recycled, existing methods of recycling washing fluids involve either offline sedimentation or online filtration.

[5] Offline sedimentation refers to the process in which used cleaning solution is pumped out of the machinery and allowed to settle. The settling process requires multiple days to complete. After the process is completed, supernatant is pumped back into machinery for reuse. This process is beneficial because it does not influence production as it is performed offline and it is considered to be reliable. However, offline sedimentation requires large tanks, lots of space, and pumps. Additionally, the water temperature of the alkali metal hydroxide solutions usually drops during the sedimentation process requiring additional heating steps before the solution can be reused.

[6] Online filtration refers to the process of pumping out used cleaning solution and filtering it online with the machinery. After the alkali metal hydroxide is filtered it is returned to the bottle washing nozzle system. Benefits of this process include the use of small equipment. Online operation ensures the solution temperature remains the same after purification. However, the filtration media clogs easily, requiring frequent cleaning or replacement. Due to these problems, the filtration method can be costly and time consuming.

[7] It is against this background that the present disclosure is made. Techniques and improvements are provided herein.

SUMMARY

[8] In summary, the present disclosure relates to methods and compositions for recycling washing solutions. In particular, the present disclosure describes methods and systems for eliminating solid waste from washing solutions containing alkali metal hydroxide in order to reuse the washing solution. Various aspects are described in this disclosure, which include, but are not limited to, the following aspects.

[9] In one aspect, a method of recycling hydroxide for use in an industrial process is described. A fluid is collected from an industrial process, wherein the fluid comprises an alkali metal hydroxide, water, and suspended solids. The solids are separated from the fluid using a centrifuge into permeate and retentate. The permeates include at least 50% of the alkali metal hydroxide of the fluid. The permeate is returned to the industrial process, where collecting and separating are done in-line with the industrial process.

[10] In another aspect, a system for recycling washing solutions comprising hydroxide is described. The system includes a tank configured to contain washing

solution, the washing solution being accessible by a washing apparatus. A disc centrifuge is in fluid communication with the tank, the disc centrifuge is configured to separate solids from the washing solution by rotating at a speed of 3000 to 15000 rpm.

[11] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[12] FIG. 1 is a diagram of a bottle-washing alkali metal hydroxide recovery system.

[13] FIG. 2 shows solids removal and active content recovery performance via industrial scale centrifuge treatment.

DETAILED DESCRIPTION

[14] Various embodiments will be described in detail with reference to the drawings, wherein like reference numerals represent like parts and assemblies throughout the several views. Reference to various embodiments does not limit the scope of the claims attached hereto. Additionally, any examples set forth in this specification are not intended to be limiting and merely set forth some of the many possible embodiments for the appended claims.

[15] A method of recycling fluid from industrial processes is described. In particular the fluid may be a solution including alkali metal hydroxide that may be recovered from a bottle washing process. Centrifuge technology is used to separate waste solids from the solution so that the alkali metal hydroxide and other washing additives can be reused in additional washing cycles.

[16] The beverage industry includes the making of beer, wine, distilled spirits, soda, dairy-, plant-, and nut-based beverages and milks, bottled carbonated and still water, and juice. In these industries, glass and PET bottles are often reused. Before the old bottles can be filled with new beverage, they must be cleaned and sanitized. Heated solutions including hydroxides (such as alkali metal hydroxide) and other washing additives (such as the Stablon products from Ecolab®) are circulated, sprayed, and otherwise agitated at and around the bottles to remove all soil and contaminants.

[17] Suitable washing additives include sequestering agents, dispersants, surfactants, other cleaning agents, and combinations thereof. Other examples of suitable bottle washing additives include BEAUCLEAN line of products produced by BEAUCHEM, SATOL® brand bottle washing additives, DEHYPON® detergent powder additives produced by BASF, or the DIVO line of bottle washing additives produced by DIVERSEY™.

[18] Dirty, used glass bottles are received at a plant and are sent through a bottle washing machine. Such machines typically have multiple compartments and wash the bottles in multiple phases. In one example, a bottle washing machine has four compartments. The bottles are first pre-rinsed with warm reclaimed water (waste water from prior washing cycles). The bottles are then soaked in a series of compartments filled with hydroxide solution. After soaking in hydroxide solution, the bottles are soaked in hot water to remove the hydroxide solution. Finally, the bottles are rinsed. In one embodiment, the bottles are first rinsed with secondary reclaimed water, then primary reclaimed water, then fresh water. In some embodiments, the bottles are rinsed in potable water after cleaning.

[19] Hydroxide solutions used in bottle washing processes can include alkali metal hydroxides (e.g., sodium hydroxide or potassium hydroxide) as well as other additives to aid in washing, such as surfactants. In one embodiment, the hydroxide solution includes sodium hydroxide and at least one bottle washing additive. Exemplary bottle washing additives include surfactants, chelating agents, and rinse aids.

Surfactants

[20] Surfactants may include nonionic, cationic, anionic, amphoteric, or zwitterionic surfactants. Preferred surfactants have superior cleaning properties, including mold removal, and are also compatible for use on polyethylene terephthalate containers. They may also provide foam control and help with sheeting or drying of the bottles. PET By the latter, it is meant that the surfactants act as a protectant in that the containers do not exhibit corrosion or hazing from the alkaline cleaning composition. While highly alkaline compositions are useful for cleaning glass, they tend to cause corrosion and hazing when used on polyethylene terephthalate. However, effective cleaning is almost impossible without some alkalinity. Thus, preferred surfactants act to protect the polyethylene terephthalate.

[21] Exemplary deterative/mold removal surfactants include, but are not limited to, the C4 to C20 sodium alkyl diphenylene oxide disulfonates, ethoxylated alcohol sulfonates, alkyl polyether phosphate esters, aryl polyether phosphate esters, alkylaryl polyether phosphate esters, polycarboxylated ethylene oxide condensates of fatty alcohols, alkamides, alcohol ethoxylates, alkylamine ethoxylates, ethylene oxide/propylene oxide copolymers, and mixtures thereof.

Chelating Agents/Sequestrants

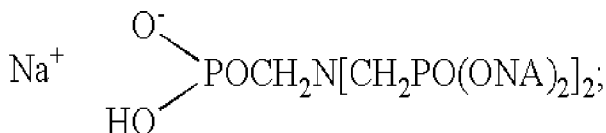
[22] The bottle washing additives may include at least one chelating agent/sequestrant. Exemplary sequestering or chelating agents include sodium gluconate, hydroxyethylidene disphosphonic acid (HEDP), aminotris(methylenephosphonic acid) (ATMP), gluconic acid, citric acid, lactic acid, phosphates, phosphonates, and organic phosphine.

[23] Exemplary phosphates include monomers of phosphoric acid, polymers of phosphoric acid, salts of phosphoric acid or combinations thereof; ortho phosphates, meta phosphates, tripolyphosphates, or combinations thereof; phosphoric acid; alkali metal, ammonium and alkanolammonium salts of polyphosphates (e.g. sodium tripolyphosphate and other higher linear and cyclic polyphosphate species, pyrophosphates, and glassy polymeric meta-phosphates); amino phosphates; nitrilotrismethylene phosphates; and the like; or a combination thereof. Preferred phosphates include phosphoric acid, and monomers, polymers, and salts thereof, and the like, or a combination thereof.

[24] Exemplary phosphonates include a wide variety of phosphonic acids and phosphonate salts, such as organophosphonates. As used herein, organic phosphonate or organophosphonate refers to organic phosphonates lacking any amino or imino (e.g. nitrogen) moieties. The phosphonic acid or phosphonate can include a low molecular weight phosphonocarboxylic acid such as one having about 2–4 carboxylic acid moieties and about –3 phosphonic acid groups. Some examples of organic phosphonates include 1-hydroxyethane-1,1-diphosphonic acid; $\text{CH}_3\text{C}(\text{OH})[\text{PO}(\text{OH})_2]_2$; 1-phosphono-1-methylsuccinic acid, phosphonosuccinic acid; 2-phosphonobutane-1,2,4-tricarboxylic acid; other similar organic phosphonates; and mixtures thereof. Additional suitable phosphonates include phosphorous acid, H_3PO_3 , and its salts.

[25] Amino phosphonates refer to phosphonates which have nitrogen moieties, e.g. amino or imino. Examples of amino phosphonates include, but are not limited to ethylene diamine tetramethylene phosphonates; nitrilotrismethylene phosphonates;

diethylenetriamine pentamethylene phosphonates; aminotri(methylenephosphonic acid): $N[CH_2PO(OH)_2]_3$; aminotri(methylenephosphonate), sodium salt:



2-hydroxyethyliminobis(methylenephosphonic acid): $HOCH_2CH_2N[CH_2PO(OH)_2]_2$; diethylenetriaminepenta(methylenephosphonic acid):

$(HO)_2POCH_2N[CH_2PO(OH)_2]_2$; diethylenetriaminepenta(methylenephosphonate), sodium salt: $C_9H(28-X)N_3NaXO_{15}P_5$ ($x=7$);

hexamethylenediamine(tetramethylenephosphonate), potassium salt: $C_{10}H(28-x)N_2K_xO_{12}P_4$ ($x=6$); bis(hexamethylene)triamine(pentamethylenephosphonic acid):

$(HO)_2POCH_2N[(CH_2)_6N[CH_2]_2]_2$. These amino phosphonates commonly contain alkyl or alkaline groups with less than 8 carbon atoms. Preferred amino phosphonates include, for example, aminotris methylenephosphonic acid: $N[CH_2PO_3H_2]_3$ available from Monsanto Chemical Co. under the tradename of DEQUEST® 2000 and also available as Briquest 301-50A, and Amino Tri(Methylene Phosphonic Acid) 50%, low ammonia from Albright & Wilson; and salts thereof.

[26] Phosphonic acids can be used in the form of water soluble acid salts, particularly the alkali metal salts, such as sodium or potassium; the ammonium salts; or the alkylol amine salts where the alkylol has 2 to 3 carbon atoms, such as mono-, di-, or triethanolamine salts.

Rinse Aids

[27] Bottle washing additives may include rinse aids to improve water drainage or removal from treated surfaces or improve drying of the surface. Generally, rinse aid formulations contain a wetting or sheeting agent combined with other optional ingredients. The rinse aids are capable of reducing the surface tension of the rinse water to promote sheeting action and/or to prevent spotting or streaking caused by beaded water after rinsing is complete. Examples of sheeting agents include, but are not limited to: polyether compounds prepared from ethylene oxide, propylene oxide, or a mixture in a homopolymer or block or heteric copolymer structure. Such polyether compounds are known as polyalkylene oxide polymers, polyoxyalkylene polymers or polyalkylene

glycol polymers. Such sheeting agents require a region of relative hydrophobicity and a region of relative hydrophilicity to provide surfactant properties to the molecule.

[28] After one or more washing cycles have been completed using the hydroxide solution, the solution can contain 2.5% hydroxide, 0.25% bottle washing additives, and 0.074% suspended solids, for example. Other ratios are possible. In some embodiments, the solution can include from 1 to 5% alkali metal hydroxide, from 1.5 to 4% alkali metal hydroxide, or from 2 to 3% alkali metal hydroxide. In some embodiments, the solution can include 0.1 to 1% bottle washing additives, 0.15 to 0.8% bottle washing additives, or 0.2 to 0.5% bottle washing additives. In some embodiments, the solutions do not include any bottle washing additives. In some embodiments, the solutions contain from 0.01 to 0.15% suspended solids, from 0.025 to 0.125% suspended solids, or from 0.05 to 0.1% suspended solids.

[29] The hydroxide and bottle washing additives lose efficacy as the amount of suspended solids increases in the solution. One solution to this problem is to continue to add more hydroxide and bottle washing additives. However, if the suspended solids are removed, the hydroxide and bottle washing additives do not need to be replenished as frequently.

[30] A centrifuge machine is adapted for solid/liquid separation in the waste alkali metal hydroxide solution recovery process. The centrifuge is preferably constructed from material that is resistant to hydroxide conditions and high temperatures, such as stainless steel. Hydroxide solution is continuously pumped out of the industrial machinery and enters a centrifuge drum. After centrifugation, solids and liquids are separated and purified hydroxide solution is pumped back to an alkali metal hydroxide tank within the industrial machinery.

[31] Centrifuges suitable for separating solids from liquids can be used to implement the methods herein. Such centrifuges include disc stack centrifuges, tubular bowl centrifuges, chamber bowl (solid bowl) centrifuges, and decanter centrifuges.

[32] Chamber bowl or decanter centrifuges can typically rotate at a speed of 1000-6000 rpm, resulting in a force of 2000-3000 times that of gravity. Chamber bowl centrifuges also allow for continuous separation of solids from liquids, but will not achieve the same result as quickly as a disc stack centrifuge. Examples of decanter centrifuges include the NX centrifuges produced by ALFA LAVAL (Sweden) or the decanter centrifuges produced by ANDRITZ (Austria).

[33] Disc stack centrifuges can rotate at up to 10,000 rpm applying a force from 4,000 to 14,000 times gravitational force. Disc stack centrifuges are also well suited for continuous separation. In some embodiments, the disc centrifuge includes a nozzle that allows for continuous ejection of sludge. Some examples of disc stack centrifuges include the MAC centrifuges produced by MACFUGE (Italy) or the DGC/DGC centrifuges produced by CROWN MACHINERY™ (China).

[34] Disc stack centrifuges are operated using stirring speeds in the range of 3,000 to 15,000 RPM. In some embodiments, the disc centrifuge is run at a speed of from 3,000 to 8,000 RPM, from 5,000 to 10,000 RPM, from 8,000 to 10,000 RPM, or from 10,000 to 15,000 RPM. In some embodiments the disc centrifuge is run at a speed in the range of 4,000 to 14,000 RPM, 5,000 to 13,000 RPM, 6,000 to 12,000 RPM, 7,000 to 11,000 RPM, or 8,000 to 10,000 RPM. Centrifugation is performed continuously and separates solids from liquids quickly (in a matter of seconds).

[35] Tubular centrifuges (sometimes called tubular bowl centrifuges) are another alternative type of centrifuge that can be used to continuously separate solid particles from liquid. Generally, tubular centrifuges are used to separate out low percentages of suspended solids that are very small (up to 1 micron) in size. Tubular centrifuges can operate at up to 20,000 gravities of centrifugal force.

[36] The centrifugation process can be improved by the addition of suitable coagulant or flocculant. Suitable coagulants or flocculants include polyDADMAC and polyacrylic acid. However, the addition of coagulant/flocculant is not essential to this process. In some embodiments, the method is free of a coagulant or flocculant.

[37] The centrifuge recovery system can automatically start on a periodic basis. For example, treatment of the waste alkali metal hydroxide can occur once a week for some tanks or once a day for other industrial processes. Each treatment takes several hours, but the length of time ultimately depends on the alkali metal hydroxide volume and centrifuge capacity.

[38] The online centrifuge alkali metal hydroxide cleaning process can be considered a first-order reaction, and the reaction speed depends on the centrifuge treatment capacity (C, ton/h, and the alkali metal hydroxide volume (V, Ton) of the washing machine. Theoretically the ratio of residual contaminant concentration (C_t) to original contaminant concentration (C_o) would be

$$\frac{C_t}{C_o} = e \left[-t * \left(\frac{C}{V} \right) \right].$$

[39] If targeting 90% contaminant to be removed during the process ($C_t/C_0 = 0.1$), then $C/V = 1$, means the necessary time is V/C hours (for examples, if the dirty alkali metal hydroxide volume is 10ton, centrifuge capacity is 5 ton/h, then the needed time is 2 h to reach 90% contaminant removal). In other embodiments, probes can be utilized to determine when alkali metal hydroxide recovery and recycling is needed for a particular piece of machinery. Probes measure the quality of the hydroxide solution based on factors such as turbidity. If turbidity is above a certain amount (e.g. 500NTU), the centrifuge system will automatically start and run until the turbidity is reduced to less than a preset value (e.g. 150 NTU). The turbidity trigger value can differ based on the particular goals for alkali metal hydroxide quality and how easily the solids separate from liquids.

[40] In one example, the centrifuge cleaning process begins when turbidity reaches a value in the range of 300 to 1,200 NTU. In other embodiments, the cleaning process will initiate when the turbidity of the alkali metal hydroxide solution is in the range of 300 to 500 NTU, 400 to 600 NTU, 500 to 700 NTU, 600 to 800 NTU, 700 to 900 NTU, 800 to 1,000 NTU, 900 to 1,100 NTU, or 1,000 to 1,200 NTU. In some embodiments, the cleaning process will begin when the turbidity is recorded at a value in the range of 400 to 1,100 NTU, 500 to 1,000 NTU, or 400 to 900 NTU. In some embodiments, the cleaning process will initiate when the turbidity of the alkali metal hydroxide solution reaches at least 300 NTU, at least 500 NTU, at least 700 NTU, or at least 900 NTU.

[41] In some embodiments, the cleaning process will stop when the turbidity of the alkali metal hydroxide solution is in the range of 30 to 500 NTU. In other embodiments, the cleaning process will cease when the turbidity of the alkali metal hydroxide solution is in the range of 30 to 100 NTU, 100 to 200 NTU, 150 to 250 NTU, 200 to 300 NTU, 250 to 350 NTU, 300 to 400 NTU, 350 to 450 NTU, or 400 to 500 NTU. In some embodiments, the cleaning process will automatically stop when the turbidity level is recorded at a value of 400 NTU or less, 300 NTU or less, 200 NTU or less, or 100 NTU or less.

[42] In some embodiments, various coagulants and flocculants can be used to aid separation of liquids and solids. Coagulants are charged chemical molecules that neutralize opposite charges of suspended solids and cause the suspended particles of solid to stick together. Suitable coagulants include natural or synthetic polymers having anionic or cationic charges. Such coagulants can include cationic organic coagulants

such as polyamines. One example of a polyamine is polydiallyldimethyl ammonium chloride (pDADMAC or polyDADMAC). Other synthetic cationic polymers include Epichlorohydrin/dimethylamine polymer (ECH/DMA), poly-epi-DMA, and Cationic Polyacrylamides (CPAMs). Other coagulants can include anionic polymers such as anionic polyacrylamides (APAMs) and sulfate polysaccharides. Anionic charged polyacrylic acid can also be used. In some embodiments, nonionic polymers can be used such as polyacrylamides (PAMs). In some embodiments, inorganic coagulants such as aluminum and iron salts can also be used. In some embodiments, suitable flocculants can be used instead of or in addition to coagulants. The amount of coagulant and/or flocculant added to the solution depends on the conditions of the solution to be treated.

[43] After this process is complete, clean alkali metal hydroxide can be sent back to a hydroxide tank in the bottle washing machine. This cleaned hydroxide solution can be reused for future cycles of washing. However, in some instances, additional alkali metal hydroxide and/or bottle washing additives may be added to the solution to maintain a desired concentration of chemicals for the most effective cleaning. Generally, the additional alkali metal hydroxide and additives would be dosed directly into the hydroxide tank to maintain a desired concentration.

[44] In some embodiments, containers are sanitized for re-use after they are washed. Such containers can include beverage bottles that are made of glass such as beer bottles. Containers can be sanitized using one or more of heat, ultraviolet light, or treatment with sanitizing agents such as bleach or alcohol.

[45] There are several benefits to recovering hydroxides from industrial processes. First it saves on the cost of hydroxidethe hydroxides used in these processes such as bottle washing. Additionally, chemical cost for other washing chemicals can be reduced since waste hydroxide typically also includes washing aid chemicals. Recovery of alkali metal hydroxide can eliminate or reduce the need for an alkali metal hydroxide renewal process, which often takes about 8 hours. This results in improved production efficiency which can be of particular importance for peak production season for the beer bottling industry.

[46] Another benefit is elimination or reduction of waste hydroxide discharge to wastewater plants. Wastewater loading pressure can be reduced and also the cost of treating the waste hydroxide before discharge can be reduced. Typically, waste

hydroxide solution must first be neutralized with an acidic solution. Finally, cleaner alkali metal hydroxide improves the bottle washing performance.

[47] FIG. 1 illustrates an example schematic diagram of a bottle wash recycling system 100. The recycling system 100 operates to remove solid waste from the remaining liquids used to wash bottles. The liquids include bottle washing additive and alkali metal hydroxide. The recycling process purifies the liquid wash for reuse.

[48] The recycling system 100 includes at least a bottle washer hydroxide tank 102 and a centrifuge 106. The hydroxide tank 102 is used to store hydroxide and other materials in solution that are used in bottle washing cycles. The hydroxide tank 102 can also store bottle washing additives as well. The centrifuge 104 is preferably a disc type centrifuge, as described above. In some embodiments dosing system 104 can be included to provide coagulant or flocculant chemicals before the turbid hydroxide solution is fed into the centrifuge 106. Examples of coagulants/flocculants include polyDADMAC and polyacrylic acid. The coagulants/flocculants can be dosed at 5-20ppm. In some embodiments, a washing additive reservoir 114 and a hydroxide reservoir 116 can be configured to dose additional amounts of washing additives and hydroxide to the hydroxide tank 102 as needed to maintain a desired concentration of each.

[49] After the turbid hydroxide is centrifuged by the centrifuge 106, solid sludge is removed as waste and recycled liquid including hydroxide is returned to the bottle washer hydroxide tank 102. The recycled hydroxide solution can also include bottle washing additives in solution that can be reused for another cycle of bottle washing. The sludge contains water, hydroxide, and a high concentration of suspended solids and can be discharged to the waste water treatment plant. The recycled hydroxide solution can be supplied with additional bottle washing additives before being used for another cycle of washing bottles.

[50] In some embodiments, a probe 108 can be installed in the bottle washer hydroxide tank 102 in order to monitor conditions of the hydroxide solution. As mentioned above, the probe 108 can measure turbidity of the hydroxide solution and communicate turbidity values to a control panel 110. The control panel 110 operates to activate the centrifuge 106 when the control panel 110 has determined that a hydroxide recycling cycle needs to be performed. The control panel 110 can base the activation on turbidity values reaching above a predetermined value, at which time the control panel 110 will communicate an activation signal to the centrifuge 106. For example, if the

turbidity of the solution in the bottle washer hydroxide tank reaches a level of 500 NTU or above, the control panel 110 would initiate a recycling cycle. After the probe 108 communicates to the control panel 110 a turbidity value below another predetermined value, the control panel 110 will communicate a deactivation signal to the centrifuge 106. For example, if the turbidity of the solution within the hydroxide tank 102 falls below 150NTU, the control panel 110 will stop the recycling process.

[51] In one example, a method of recycling sodium hydroxide for use in an industrial washing process can be implemented using the bottle wash recycling system 100 of FIG. 1. A turbidity level of at least 500 NTU is detected in washing solution by a probe in an industrial washing tank. The washing solution includes at least sodium hydroxide and bottle washing additive. This detection initiates a recycling process which begins by transporting washing solution from the industrial washing tank to a disc centrifuge. In some embodiments, a portion of the washing solution is continuously transported to the disc centrifuge. The disc centrifuge is operated at a speed of from 3,000 to 15,000 RPM to separate and remove suspended solids from the washing solution. Washing solution is then transported back to the industrial washing tank. In some embodiments, a portion of washing solution is being continuously transported from the disc centrifuge to the industrial washing tank. When the probe detects a turbidity level of less than 150 NTU in the washing solution in the industrial washing tank, the recycling process is deactivated.

EXAMPLES

[52] Suspended solids were tested with APHA Method 2540D. This is a standard method of determining the total suspended solids (TSS) in water or wastewater. Glass fiber filter disks are inserted into a filtration apparatus and suction is applied. Samples are pipetted onto the filter and the filter is washed with water. The filter is transferred to a weighing dish and dried for at least 1 hour at 103 to 105°C. The weight of the sample is taken and the total amount of suspended solids is calculated based on the total volume. Bottle washing additive content was tested by measuring levels of phosphonate content in the samples by titration. Sodium thiosulfate and Indicator S was added to a sample. The pH was adjusted to 4.5 with hydrochloric acid. The sample was titrated with thorium nitrate until the color turned purple. The concentration of washing additive was calculated based on the drops of thorium nitrate.

Example 1

[53] Centrifugation was used to remove waste solids from sodium hydroxide containing solutions. Samples taken from different hydroxide tanks were examined before and after centrifugation to assess performance. The hydroxide tanks contain liquid recovered after bottle washing processes using alkali metal hydroxide and other bottle washing additives. Table 1 includes turbidity values recorded in three tanks at a first brewery site and one tank at a second brewery site. Tank 1 had a concentration of 2.5% alkali metal hydroxide, Tank 2 had a concentration of 1.5% alkali metal hydroxide, and Tank 3 had a concentration of 0.5% alkali metal hydroxide. The samples were processed with a laboratory centrifuge at a speed of 4000 rpm for 5 minutes.

Table 1

Samples	Tank 1	Tank 2	Tank 3	Tank 4
Before centrifuge	1500 NTU	960 NTU	731 NTU	564 NTU
After centrifuge	165 NTU	51 NTU	30 NTU	45 NTU

[54] As can be seen from the results displayed in Table 1, the samples are much less turbid after centrifugation. The majority of suspended solids are settled at the bottom of the centrifuge tube. The turbidity was reduced to 30-170 NTU (Nephelometric Turbidity Unit) from 500-1500 NTU.

[55] Similar results are shown with another set of three tanks at a third brewery site. The results of Table 2 also show a reduction in turbidity after centrifugation. The turbidity was reduced to 50-120 NTU from 500-1250 NTU.

Table 2

Samples	Tank 1	Tank 2	Tank 3
Before centrifuge	1250 NTU	730 NTU	540 NTU
After centrifuge	120 NTU	85 NTU	55 NTU

Example 2

[56] The centrifuge hydroxide purification performance was further checked with industry size disc centrifuge equipment (DHC300, FuYi Liquid Separation Technology Co. Ltd). The centrifuge was run at a speed of 7000-1000 rpm, with liquid treating capacity of two tons per hour.

[57] In this pilot test, 50L waste alkali metal hydroxide from a beer bottling plant was heated to about 80°C. The raw waste hydroxide sample was continuously pumped into the centrifuge equipment and treated. The purified hydroxide samples were collected from a tube on the top of the centrifuge equipment.

[58] FIG. 2 shows the pilot test result after separation with an industrial disc centrifuge. After centrifuge treatment, the alkali metal hydroxide sample suspend solids (SS) dropped from 740 to 155ppm equating to a 79% SS removal rate (FIG. 5a). At the same time, as shown in FIG. 5b and Table 3, the active hydroxide remains at 88.7% after purification and the bottle washing aid recovery (organic phosphate) was 94%.

Table 3

	COD mg/L	Active hydroxide %	Organic phosphate mg/L
Raw Alkali Metal Hydroxide	10000	3.55	540
After centrifuge	8400	3.15	510

[59] While certain embodiments have been described, other embodiments may exist. While the specification includes a detailed description, the scope of the present disclosure is indicated by the following claims. The specific features and acts described above are disclosed as illustrative aspects and embodiments. Various other aspects, embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to one of ordinary skill in the art without departing from the spirit of the present disclosure or the scope of the claimed subject matter.

Claims

1. A method of recycling hydroxide for use in an industrial process comprising:
collecting a fluid from an industrial process, wherein the fluid comprises an alkali metal hydroxide, water, and suspended solids;
separating the solids from the fluid using a centrifuge into permeate and retentate, wherein the permeate comprises at least 50% of the alkali metal hydroxide of the fluid; and
returning the permeate to the industrial process, wherein the collecting and separating are done in-line with the industrial process.
2. The method of claim 1, wherein the industrial process is a washing process.
3. The method as in claim 1 or 2, wherein the fluid further comprises washing additives.
4. The method of claim 3, wherein the permeate further comprises at least 80% of the washing additives from the fluid.
5. The method as in claim 3 or 4, wherein the bottle washing additives are selected from the group consisting of sodium gluconate, HEDP, ATMP, EDTA, and surfactants.
6. The method as in any one of claims 1-5, further comprising adding a coagulant or flocculant to the fluid.
7. The method of claim 6, wherein the coagulant or flocculant is selected from the group consisting of polyDADMAC, poly-epi-DMA, and polyacrylic acid.
8. The method as in any one of claims 1-7, wherein the fluid is substantially free of coagulant and flocculant.
9. The method as in any one of claims 1-8, wherein the method uses sodium hydroxide to wash bottles.

10. The method as in any one of claims 1-9, wherein the permeate comprises at least 75% of the alkali metal hydroxide of the fluid.
11. The method as in any one of claims 1-9, wherein the permeate comprises at least 90% of the alkali metal hydroxide of the fluid.
13. The method as in any one of claims 1-9, wherein the permeate comprises at least 99% of the alkali metal hydroxide of the fluid.
14. The method as in any one of claims 1-9, wherein the permeate comprises 50%-99% of the alkali metal hydroxide of the fluid.
15. The method as in any one of claims 1-14, further comprising adding alkali metal hydroxide or bottle washing additives to the permeate.
16. The method as in any one of claims 1-15, further comprising disposing of the retentate.
17. The method as in any one of claims 1-16, wherein the fluid is collected in a tank that can be accessed for multiple washing cycles and the method further comprises monitoring turbidity of the fluid in the tank using a probe and activating the centrifuge when the turbidity of the fluid reaches at least 500 NTU.
18. A system for recycling washing solutions comprising hydroxide, the system comprising:
a tank configured to contain washing solution, the washing solution being accessible by a washing apparatus; and
a disc centrifuge in fluid communication with the tank, the disc centrifuge configured to separate solids from the washing solution by rotating at a speed of 3000-15000 rpm.
19. The system of claim 18, further comprising:

an apparatus configured to add a coagulating agent into the washing solution as it is sent to the centrifuge.

20. The system as in claim 18 or 19, further comprising:

a probe configured to measure turbidity of the washing solution in the tank; and
a control panel in electronic communication with the probe and the centrifuge, the control panel operating to activate the centrifuge when the probe detects a turbidity level of at least 500 NTU and to deactivate the centrifuge when the probe detects a turbidity level of 150 NTU or less.

21. The system of claim 20, further comprising a hydroxide reservoir and a washing additives reservoir, each reservoir being in fluid communication with the tank.

22. A method of recycling sodium hydroxide used in an industrial washing process comprising:

detecting, with a probe, a turbidity level of at least 500 NTU in washing solution in an industrial washing tank, the washing solution comprising sodium hydroxide and bottle washing additive;

activating a recycling process comprising:

continuously transporting a portion of the washing solution from the industrial washing tank to a disc centrifuge;

operating the disc centrifuge at a speed of from 3,000 to 15,000 RPM to separate and remove suspended solids from the washing solution; and

continuously transporting washing solution from the disc centrifuge to the industrial washing tank;

detecting, with the probe, a turbidity level of less than 150 NTU in the washing solution in the industrial washing tank; and

deactivating the recycling process.

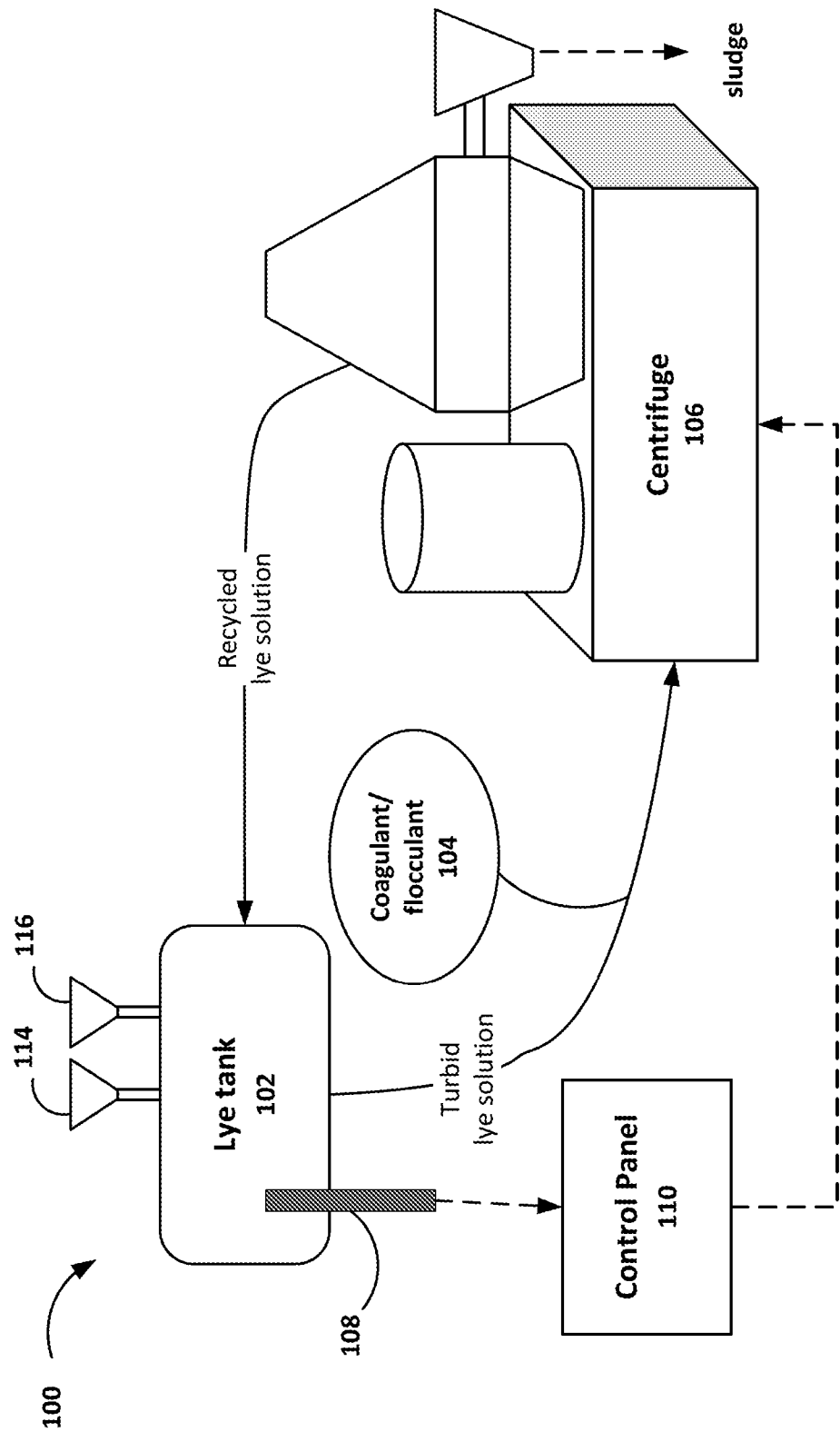
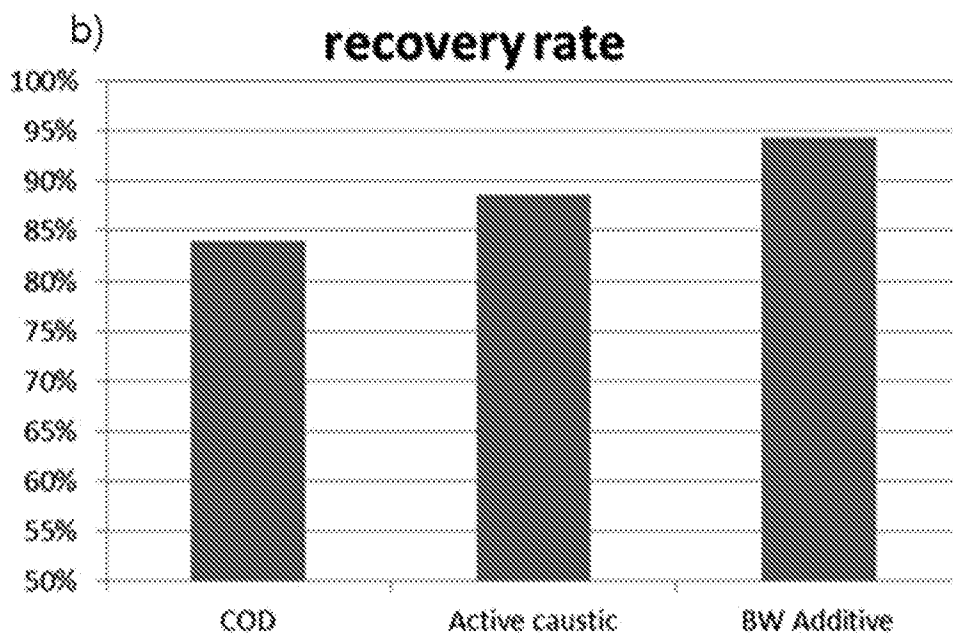
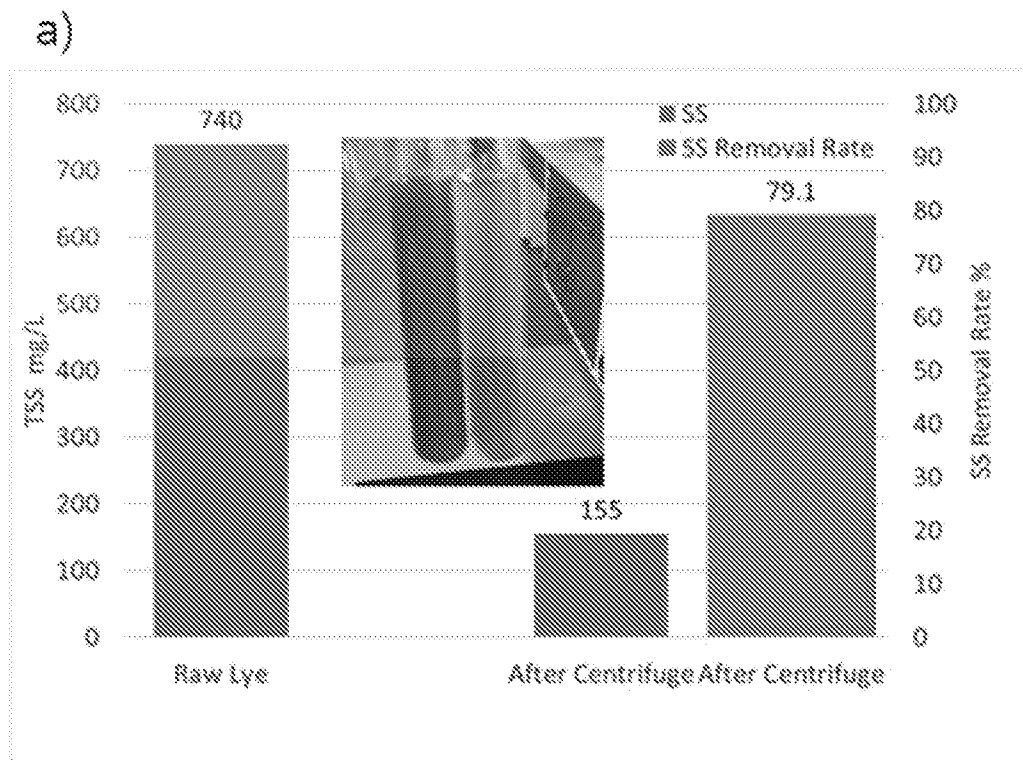


FIG. 1

**FIG. 2**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/093639

A. CLASSIFICATION OF SUBJECT MATTER

C02F 1/38(2006.01)i; A47L 15/44(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C02F,A47L

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)

CNKI,CNXTX,SIPOABS,DWPI: water,waste,sewage,hydroxide,centrifug+,separat+,suspend+,solid,particle,wash+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 107265564 A (WISDRI ENG & RES INC LTD CO) 20 October 2017 (2017-10-20) See description, page 2, figure 1	1-22
Y	CN 103501677 A (ECOLAB USA INC) 08 January 2014 (2014-01-08) See description, page 2 to page 16, figure 1	1-22
A	US 6001190 A (GEN ELECTRIC) 14 December 1999 (1999-12-14) See the whole document	1-22
A	US 2006112824 A1 (ASHLAND LICENSING & INTELLECTU) 01 June 2006 (2006-06-01) See the whole document	1-22
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☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"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

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Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2019/093639

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