

TITLE: APPARATUS AND METHOD FOR ADAPTIVELY ANALYZING ONE OR
MORE PHYSICOCHEMICAL PROPERTIES

Technical Field

5

[0001] Various embodiments relate to an apparatus for adaptively analyzing and controlling one or more physicochemical properties, as well as a method therefor. More specifically, the various embodiments may relate to adaptive analysis and control of a liquid sample or solution, for example, pulp/water sample, industrial water or recycled water.

10

Background

[0002] The physicochemical analysis of a pulp/water sample is important and applicable in various industries such as mining, metallurgical, constructions, medicine, amongst others. For example in the fields of mining and metallurgical, the analysis and control of physicochemical (or interchangeably referred to as ionometric or ionic) compositions of the pulp/water sample may result in enrichment of mineral ores.

15

[0003] As the analysis and control processes may be repeated, automation has been adopted to improve efficiency and consistency. Automatic control of the physicochemical components of the liquid phase of flotation slurries and solutions are known to be carried out for various purposes.

20

[0004] Such automatic control provides a relatively simple and low cost solution by involving automatic sensors to determine the ionic composition of pulps using a potentiometric method based on measuring electromotive force (EMF) of galvanic cells. The galvanic cells include indicator ion-selective electrodes, reference electrodes, and may further include submersible fittings and electronic transducers. The electrodes may be made of various materials, typically metals, for example, zinc, copper, amongst others.

25

[0005] The disadvantages of devices based on the use of the potentiometric method are insufficiently high selectivity of measurements due to the effect on the EMF of numerous

30

ions of uncontrolled substances present in the pulp, and gradual overgrowth of the electrode surfaces with insoluble deposits that distort the measurement results.

[0006] A concentrator of pulp filtrate KFP-5 by Uralavtomatika Engineering LLC, Russia, is an example of a device for automatic control of physical and chemical components of pulp, and contains a control controller, a sampler, a storage tank, control valves, a measuring cuvette with concentration sensors, as well as a transfer pump. The concentrator provides automatic selection of pulp filtrate, accumulation of the amount of liquid required for analysis, supply of the accumulated filtrate to a measuring cuvette and subsequent analysis by the potentiometric method in the controlled material in terms of CaO ions and pH levels. While the concentrator may partially solve the problem of increasing the selectivity of measurements and protecting the surfaces of the measuring electrodes from overgrowing with insoluble deposits, there remains drawbacks that lead to low measurement accuracy.

[0007] Such drawbacks may include a filter cartridge of the device being exposed to significant loads due to a need to filter a large volume of the solid phase of the pulp, which inevitably lead to a rapid clogging of the working surface of the filter, a change in its filtering properties and, as a consequence, to a distortion of the concentration of controlled components in the analyzed product sample. Furthermore, the use of the potentiometric method for measuring solutions is effective only in the region of low concentrations, since with a significant increase in concentration, a saturation region appears, in which the value of specific conductivity does not depend on the amount of controlled substance.

[0008] Thus, there is a need for an apparatus and method for automatic control of physicochemical compositions of a solution, more specifically, pulp/water sample to address at least the problems mentioned above.

Summary

[0009] According to an embodiment, an apparatus for adaptively analyzing one or more physicochemical properties is provided. The apparatus may include a sampling chamber configured to receive a liquid sample and to allow the liquid sample to be separated to

obtain a supernatant of the liquid sample; a measuring chamber in fluid communication with the sampling chamber; a dosing pump arranged between the sampling chamber and the measuring chamber, wherein the dosing pump is configured to draw at least portion of the supernatant from the sampling chamber into the measuring chamber; one or more
5 sensors configured to measure one or more parameters of the at least portion of the supernatant in the measuring chamber; and a processing unit configured to control receipt of the liquid sample in the sampling chamber, and activation and deactivation of the dosing pump; to receive data for processing; and to analyze the received data with respect to previous data. The data may include the one or more parameters of the at least portion
10 of the supernatant measured by the one or more sensors, and the previous data may include one or more parameters of at least portion of a supernatant obtained from a source at an earlier point in time. The one or more parameters may be representative of the one or more physicochemical properties. The one or more sensors may include a conductivity sensor configured to measure conductivity.

15 **[0010]** According to an embodiment, a method for adaptively analyzing one or more physicochemical properties is provided. The method may include receiving a liquid sample; allowing the liquid sample to be separated to obtain a supernatant of the liquid sample; drawing at least portion of the supernatant; measuring one or more parameters of the at least portion of the supernatant; and receiving data for processing by a processing
20 unit, wherein the data includes the measured one or more parameters of the at least portion of the supernatant. The processing unit may be configured to analyze the received data with respect to previous data that includes measured one or more parameters of at least portion of a supernatant obtained from a source at an earlier point in time. The one or more parameters may be representative of the one or more physicochemical properties.

25 The one or more parameters may include conductivity.

Brief Description of the Drawings

[0011] In the drawings, like reference characters generally refer to like parts throughout
30 the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following

description, various embodiments of the invention are described with reference to the following drawings, in which:

[0012] FIG. 1A shows a schematic cross-sectional view of an apparatus for adaptively analyzing one or more physicochemical properties, according to various embodiments.

5 **[0013]** FIG. 1B shows a flow chart illustrating a method for adaptively analyzing one or more physicochemical properties, according to various embodiments.

[0014] FIG. 2 shows a schematic view illustrating the principle of operation of a device for automatic control of the physical and chemical components of pulp/water, according to one embodiment.

10

Detailed Description

[0015] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new
15
20 embodiments.

[0016] Embodiments described in the context of one of the methods or devices are analogously valid for the other methods or devices. Similarly, embodiments described in the context of a method are analogously valid for a device, and vice versa.

[0017] Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or
25
30 similar feature in the other embodiments.

[0018] In the context of various embodiments, the articles “a”, “an” and “the” as used with regard to a feature or element include a reference to one or more of the features or elements.

5 **[0019]** In the context of various embodiments, the term “about” or “approximately” as applied to a numeric value encompasses the exact value and a reasonable variance.

[0020] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

10 **[0021]** As used herein, the phrase of the form of “at least one of A or B” may include A or B or both A and B. Correspondingly, the phrase of the form of “at least one of A or B or C”, or including further listed items, may include any and all combinations of one or more of the associated listed items.

15 **[0022]** Various embodiments may provide a device for automatic control of the physical and chemical components of pulp and water. The device for automatic control of the physicochemical components of the pulp has high reliability due to the use of a more efficient scheme for obtaining the filtrate and allows to increase the accuracy of measurements through the use of a set of additional tools that expands the range and accuracy of concentration control.

20 **[0023]** FIG. 1A shows a schematic cross-sectional view of an apparatus 100 for adaptively analyzing one or more physicochemical properties, in accordance with various embodiments. In FIG. 1A, the apparatus 100 may include a sampling chamber 102 configured to receive a liquid sample and to allow the liquid sample to be separated (or interchangeably referred to as settled or sedimentated) to obtain a supernatant of the liquid sample; a measuring chamber 104 in fluid communication with the sampling chamber 102; and a dosing pump 106 arranged between the sampling chamber 102 and the measuring chamber 104. The dosing pump 106 may be configured to draw at least portion of the supernatant from the sampling chamber 102 into the measuring chamber 104.

25 **[0024]** The liquid sample may include a solution such as industrial water or recycled water, a suspension or a slurry such as a pulp-containing sample. The pulp-containing sample may be referred to as pulp/water. The configuration of and the setup within the

30

sampling chamber 102, along with the use of the dosing pump 106, allows for the liquid sample to be more accurately prepared prior to analysis.

[0025] The apparatus 100 may also include one or more sensors 108 configured to measure one or more parameters of the at least portion of the supernatant in the measuring chamber 104. The one or more parameters may be representative of the one or more physicochemical properties. The one or more sensors 108 may include a conductivity sensor configured to measure conductivity, and may be disposed in the measuring chamber 104, allowing for contact with the at least portion of the supernatant in the measuring chamber 104, as depicted by a line 126. In other words, the one or more parameters may include conductivity. Conductivity, in general, is the ability of a material to conduct electricity, heat, fluid or sound. For example, the conductivity sensor may be used to determine the ability of the at least portion of the supernatant to conduct electricity.

[0026] In context of various embodiments described herein, conductivity may also include the electrical conductivity of a solution (e.g. the at least portion of the supernatant) measured during the course of a chemical reaction. The measurement of such electrical conductivity may be referred to as conductometry which is the determination of the quantity of a material present in a mixture by measurement of its effect on the electrical conductivity of the mixture. In other words, conductometry may allow for concentration of a solution to be determined. Accordingly in other embodiments, the conductivity sensor may include a conductometric sensor with a design, immersion fitting and electronic transducer suitable for the application at hand.

[0027] The apparatus 100 may additionally include a processing unit 110 configured to control receipt of the liquid sample in the sampling chamber 102, and activation and deactivation of the dosing pump 106; to receive data for processing; and to analyze the received data with respect to previous data. The data may include the one or more parameters of the at least portion of the supernatant measured by the one or more sensors 108, and the previous data may include one or more parameters of at least portion of a supernatant obtained from a source 112 at an earlier point in time. The data and the previous data may include parameters of the same types. The one or more parameters may be representative of the one or more physicochemical properties. The previous data

may be obtained at the earlier point in time using the apparatus 100, and may be stored in a memory unit (not shown in FIG. 1A). In some embodiments, the memory unit may be integrated in the processing unit 110.

[0028] The source 112 may provide the liquid sample for the sampling chamber 102 via a valving control as depicted by a dotted line 120. The sampling chamber 102 and the dosing pump 106 may be coupled via another valving control as depicted by a line 122. These valving controls 120, 122 may include hydraulic valves. An outlet of the dosing pump 106 may be in fluid communication with an inlet of the measuring chamber 104, as depicted by a line 124. The processing unit 110 may be electrically coupled, by wired or wirelessly, to the sampling chamber 102 to control valving controls therein (as depicted by a line 130), the dosing pump 106 to control activation or deactivation thereof (as depicted by a line 132), and the one or more sensors 108 to receive measured data therefrom (as depicted by a line 128).

[0029] In the context of various embodiments, the phrase “in fluid communication” may refer to direct or indirect coupling or connection for fluid to pass through. The term “draw” may mean the act of sampling.

[0030] The one or more sensors 108 may further include a potentiometric sensor configured to measure an electrode potential in the at least portion of the supernatant in the measuring chamber 104, and thus, the one or more parameters may additionally include electrode potential.

[0031] The expression “one or more sensors” may mean one sensor, or a plurality of sensors. The plurality of sensors may comprise a number of sensors of the same type that may be configured differently, or a number of different types of sensors. The expression “one or more parameters” may mean one parameter, or a plurality of different types of parameters. The expression “one or more physiochemical properties” may mean one physiochemical property, or a plurality of different types of physiochemical properties. The expression “representative of” used in the context of various embodiments in a form of R being representative of P may refer to R and P having a relationship between each other, wherein the relationship may be established mathematically. For example, if R is a parameter of conductivity, P may be a physiochemical property of the conductivity of the measured sample. In another example, if R is a parameter of electrode potential, P may be

a physiochemical property of the ionic conductivity of the measured sample. Other examples of physiochemical properties of a liquid sample may include, but is not limited to, pH level, mineral level, turbidity, amongst other. Different types of physiochemical properties may be referred to depending on the application required from the analysis.

5 **[0032]** In various embodiments, the sampling chamber 102 may include a first receptacle configured to receive the liquid sample from the source 112 and to allow the liquid sample to settle and obtain an initial supernatant of the liquid sample; a second receptacle in fluid communication with the first receptacle; and a valve arranged between the first
10 receptacle and the second receptacle. The valve may be operable by the processing unit 110 (as depicted by the line 130) to allow at least portion of the initial supernatant to be directed from the first receptacle to the second receptacle, forming the supernatant of the liquid sample in the second receptacle.

[0033] In some embodiments, the apparatus 100 may further include a vacuum station configured to create a vacuum in the first receptacle to enable the liquid sample to be
15 transferred from the source 112. The vacuum station may be in fluid communication with the first receptacle and may be disposed in the first receptacle. The use of the vacuum station, or interchangeably referred to as a vacuum installation, eliminates the involvement of complex sampling devices and may simplify to a level of providing a hose routing made of wear-resistant material. By using the vacuum station, the liquid
20 sample may be transferred from the source 112, for example, through collector sampling. A collector (not shown in the figures) may provide collector sampling which allows expansion of the range of studies of different media, for example, circulating water, flotation materials (slurry, froth product), reagents supplied to reagent dosing points to adjust the concentration of a reagent compartment or a reagent house, a material from a
25 thickener, etc.

[0034] In other words, the apparatus 100 may be an apparatus of performing adaptive physiochemical analysis and control of a liquid sample, for example, pulp/water. The apparatus 100 may be a device for automatic control of the ionometric composition of pulp/water sample, that includes a flask that is a sample settler intended for primary
30 gravity cleaning (e.g. the first receptacle); a second flask that is a sample settler for secondary gravity cleaning (e.g. the first receptacle); a vacuum station responsible for

taking a sample from a primary source (e.g. source 112); hydraulic flow control valves (e.g. 120, 122); a dosing pump responsible for controlling the filling of the measuring chamber (e.g. 104); ionometric composition control devices (e.g. the one or more sensors 108 including the conductivity sensor and the potentiometric sensor); and a switch controller (e.g. processing unit 110).

[0035] The ionometric composition control devices may provide ionometric measurements using metal electrodes for electronic conduction, and membrane (ion-selective) electrodes for ionic conduction. For example, metal electrodes may be used to determine redox potential of a solution (inactive indicator electrodes made of noble metals such as platinum) and to measure concentration of individual ions (active electrodes). This way, pH value as well as contents of potassium and nitrates, sodium and calcium in the solution may be determined. In addition, quick and easy monitoring of fluoride contents may also be achieved. This advantageously allows for significant expansion of the range of controlled elements. For example, in addition to conductometry and pH metry, an auto-titrator may include additional analysis modules such potentiometric methods based on the metal and/or ion-selective electrodes.

[0036] The switch controller may be responsible for: collecting and storing measured values, processing them and issuing data for any external system; data collection from measuring sensors and instruments that analyze the environment being carried out by connecting to the inputs of the switch controller; control of hydraulic processes in the apparatus by controlling discrete electrical signals from the switch controller outputs.

[0037] In various embodiments, the apparatus 100 may further include a process water inlet for each of the first receptacle and the second receptacle, wherein the process water inlet is configured to supply process water into the respective first and second receptacles and clean away residues therein. The residues may include at least portion of residues of the liquid sample, and/or at least portion of the initial supernatant in the first receptacle, and/or at least portion of the supernatant in the second receptacle.

[0038] In various examples, the apparatus 100 may further include a pH sensor configured to measure pH level of the at least portion of the supernatant in the measuring chamber 104, a pH indication system configured to display the measured pH level or to provide an indication of the measured pH level in real-time, and a pH correction (or pH

adjustment) system configured to adjust pH level of the at least portion of the supernatant to a pre-defined acceptable range. The pH sensor may be included as the one or more sensors 108 disposed in the measuring chamber 104. The pH level may be included as the one or more parameters representative of the one or more physiochemical properties. The pH sensor, pH indication system and pH correction system may be examples of ionometric composition control devices mentioned above. The processing unit 110 may be configured to receive the data further including the pH level measured by the pH sensor, and to provide output information to the pH indication system and pH correction system.

[0039] In various embodiments, the one or more sensors 108 may further include an optical sensor configured to measure an optical signal representative of a physicochemical property of the at least portion of the supernatant in the measuring chamber 104. This physicochemical property may be one physicochemical property of the one or more physicochemical properties. The processing unit 110 may be configured to receive the data further including the optical signal. The optical sensor may be disposed in the measuring chamber 104. The optical sensor need not be in direct or physic contact with the at least portion of the supernatant in the measuring chamber 104.

[0040] The one or more sensors 108 may also include a further optical sensor configured to measure a further optical signal representative of a further physicochemical property of the at least portion of the supernatant in the measuring chamber 104, the further physicochemical property being different from the physicochemical property represented by the optical signal measured from the optical sensor. The processing unit 110 may be configured to receive the data further including the further optical signal. The further optical sensor may be disposed in the measuring chamber 104. The optical sensor and the further optical sensor may be two separate sensors. Similar to the optical sensor, the further optical sensor need not be in direct or physic contact with the at least portion of the supernatant in the measuring chamber 104.

[0041] The use of various combinations of optical sensors makes it possible to expand the ranges of various analyzes of samples in a measuring chamber 104. The use of various combinations of different types of sensors also enables the ranges of various analyzes of samples in a measuring chamber 104 to be expanded. Thus, the apparatus 100

may, more specifically, include two or more sensors, or three or more sensors, or four or more sensors, or so on.

[0042] In various embodiments, the processing unit 110 may be configured to process the received data using a neural network algorithm. The use of neural network algorithm(s)
5 may allow the apparatus 100, when in use, to further reduce time for analyzing results based on the received data from optical analysis (e.g. the optical sensor(s)) and measurement devices (e.g. the conductivity sensor, the potentiometric sensor, and the pH sensor).

[0043] In other words, based on the accumulated data received by the processing unit
10 110, the apparatus 100 optimizes the analysis time of the sample (pulp/water), automatically selects the necessary algorithm(s) for analyzing the sample, and enables the contents of the measurement environment (to which the sample is exposed) to be determined. This makes it possible to adaptively study the source (from which the liquid sample is extracted) depending on fluctuations in the content of chemicals, as well as
15 changes in the source itself during emergency leaks of reagents or other influences that may radically change the originally declared measurement environment. These changes may be recorded and applied to the results of the analyzed samples.

[0044] The main algorithm for controlling the apparatus 100 provides for the impact on the chemical and electrochemical composition of the liquid sample, e.g. pulp/water, using
20 chemical reagents, the dosage of which is adjusted up or down due to the data obtained by the processing unit 110 including a software complex. This is in line with a main task of changing and maintaining the chemical/electrochemical composition of the liquid sample determined at a research stage. For example, in a study determined to obtain the best zinc recovery in a main flotation, it was found necessary to maintain free CaO at
25 800mg/L. After the analysis, the apparatus (system) would determine the existing level and give a corresponding signal for the dosing pump to add lime to a required value or not to add lime at all. It may be one parameter, or it may be several parameters, such as a certain (pre-defined) pH, a certain (pre-defined) content of carbonates, a difference in potentials between two or three electrodes, amongst others. A distinctive feature of the
30 apparatus 100, as compared to existing systems, is universality due to the use of not only

one analysis circuit (e.g. conductometry or pH), but rather the use of several analysis circuits, expandable due to the adoption of new analysis modules.

[0045] The processing unit 110 may include a software and hardware complex (SHC) for managing/controlling the analysis process and controlling the preparation of the liquid sample. The SHC may include a program for controlling the hardware (various components of the apparatus 100), research software (others in addition to neural network algorithms), and client-server software. The SHC may also enable the reports to be accompanied with video materials of the study passing with the display of data, exact time and measurement results, by overlaying information on the video material.

[0046] In various embodiments, the measuring chamber 104 may be made of a non-transparent material. In other embodiments, the measuring chamber 104 may be made of an anti-abrasive material. In yet other embodiments, the measuring chamber 104 may be made of a non-transparent and anti-abrasive material. By having the measuring chamber 104 being not transparent and made of modern anti-abrasive materials, errors from ingress of external radiation sources in the optical range may be excluded or eliminated, or at least minimized. Such errors may affect the optical sensors and distort results of the study of the liquid sample. For example, an optical sensor may be a refractive sensor.

[0047] In various embodiments, the apparatus 100 may further include a drainage outlet for each of the sampling chamber 102 and the measuring chamber 104. The drainage outlet may be configured to drain out unwanted contents in the sampling chamber 102 and the measuring chamber 104. For example, the unwanted contents may refer to the contents in the sampling chamber 102 (more specifically, the first and second receptacles) and the measuring chamber 104 after measurements are made by the one or more sensors 108, or after the received data is analyzed by the processing unit 110. The unwanted contents may also refer to process water that has been used for cleaning away residues in the sampling chamber 102 and the measuring chamber 104. By draining out the unwanted contents, the sampling chamber 102 and the measuring chamber 104 may be cleaned or washed, and the next liquid sample from the source 112 or from a different source can be obtained by the apparatus 100 to repeat the adaptive physicochemical analysis on the next liquid sample.

[0048] The apparatus 100 may further include a plurality of further valves. Each further valve of the plurality of further valves may be coupled to each of the dosing pump 106, the process water inlet, and the drainage outlet. The plurality of further valves may be operable by the processing unit 110 to control flow through each of the dosing pump 106, the process water inlet, and the drainage outlet. For example, each further valve may include a hydraulic valve.

[0049] In various embodiments, the apparatus 100 may further include one or more reagent dosing units configured to supply one or more reagents to the measuring chamber 104. In order to effectively perform conductometric analysis methods, additional reagents and equipment may be employed to facilitate a suitable chemical reaction in the liquids, e.g. in the at least portion of the supernatant in the measuring chamber 104.

[0050] The number of reagent dosing units for conducting research may be limited only by the number of studies performed. This is advantageously different from other configurations that are oriented towards one or a maximum of two methods of sample research, which in turn require increased number of stations or devices. Each reagent dosing unit may be provided with a reagent dosing pump or metering pump. In various examples, additionally to the use of the conductivity sensor, the potentiometric sensor and/or the optical sensor(s) and/or the pH sensor, a number of metering pumps may be used for autotitration using indicator solutions (reagents) when a pre-defined amount of a known reagent is added to the test substance (e.g. in the at least portion of the supernatant in the measuring chamber 104). With the help of an auto-titrator, the number of defined elements may be expanded to include, for example, determination of total alkalinity and carbonate hardness water, determination of water acidity, determination of free carbon dioxide, determination of bichromate oxidizability of water (COD), amongst others.

[0051] The dosing of reagents may be carried out by microdosing with high accuracy by using modern dosing devices, depending on the required tasks and research methods. The modern dosing devices may include pumps of peristaltic type with variable output, for example but not limiting to, Watson-Marlow Pumps.

[0052] FIG. 1B shows a flow chart illustrating a method 140 for adaptively analyzing one or more physicochemical properties, in accordance with various embodiments. As shown

in FIG. 1B, at Step 142, a liquid sample is received. At Step 144, the liquid sample may be allowed to be separated (settled or sedimentated) to obtain a supernatant of the liquid sample. At Step 146, at least portion of the supernatant may be drawn. At Step 148, one or more parameters of the at least portion of the supernatant may be measured. The one or more parameters may include conductivity. At Step 150, data for processing may be received by a processing unit (e.g. 110 of FIG. 1A). The data may include the measured one or more parameters of the at least portion of the supernatant. The processing unit 110 may be configured to analyze the received data with respect to previous data that includes measured one or more parameters of at least portion of a supernatant obtained from a source (e.g. 112 of FIG. 1A) at an earlier point in time. The previous data may be stored in a memory unit (not shown in the figures). The one or more parameters may be representative of the one or more physicochemical properties.

[0053] The one or more parameters may further include an electrode potential in the at least portion of the supernatant.

[0054] The method 140 may include the same or like elements or components as those of the apparatus 100 of FIG. 1A, and as such, the same numerals are assigned and the like elements may be as described in the context of the apparatus 100 of FIG. 1A, and therefore the corresponding descriptions are omitted here.

[0055] In various embodiments, the step of receiving the liquid sample may include receiving the liquid sample from the source 112 and allowing the liquid sample to settle and obtain an initial supernatant of the liquid sample; and sampling at least portion of the initial supernatant to form the supernatant of the liquid sample.

[0056] The method 140 may further include creating a vacuum to enable the liquid sample to be transferred from the source 112.

[0057] After measuring the one or more parameters of the at least portion of the supernatant, at least one of the initial supernatant, the supernatant, or the at least portion of the supernatant may be drained out. Process water may be then supplied to clean away residues of at least one of the initial supernatant, the supernatant, or the at least portion of the supernatant.

[0058] In various embodiments, the method 140 may further include measuring one or more optical signals representative of the one or more physicochemical properties of the

at least portion of the supernatant. The data for processing by the processing unit 1100 may further include the one or more optical signals.

[0059] After receiving the data, the received data may be processed using a neural network algorithm.

5 **[0060]** In various embodiments, the method 140 may further include supplying one or more reagents to the at least portion of the supernatant. With the supplying of the one or more reagents to the at least portion of the supernatant, the number of defined elements may be expanded to include determination of total alkalinity and carbonate hardness water, determination of water acidity, determination of free carbon dioxide, determination
10 of bichromate oxidizability of water (COD), amongst others.

[0061] While the method 140 described above is illustrated and described as a series of steps or events, it will be appreciated that any ordering of such steps or events are not to be interpreted in a limiting sense. For example, some steps may occur in different orders and/or concurrently with other steps or events apart from those illustrated and/or
15 described herein. In addition, not all illustrated steps may be required to implement one or more aspects or embodiments described herein. Also, one or more of the steps depicted herein may be carried out in one or more separate acts and/or phases.

[0062] In the method 140, the analysis of the received data may allow for any changes in the physiochemical composition of the liquid sample, e.g. pulp/water sample, to be
20 observed. Such changes may be indicative of on-going variations or fluctuations in the environment where the liquid sample is obtained from. For example, based on the accumulated data, the method 140 (that may be performed by the apparatus 100) may optimize analysis time of the sample, and may also be able to determine the content(s) of the measurement environment and automatically select the necessary algorithm for
25 analyzing the samples. This makes it possible to adaptively study the supplied medium depending on fluctuations in the content of chemicals, as well as changes in the medium itself during emergency leaks of reagents or other influences that radically change the originally declared measurement environment. These changes are recorded and applied to the results of the analyzed samples.

30 **[0063]** The principle of operation of an exemplary device for automatic control of the physical and chemical components of the pulp/water will be described below.

[0064] FIG. 2 shows a schematic view illustrating the principle of operation of a device 200 for automatic control of the physical and chemical components of pulp/water, according to one embodiment. The device 200 may include the same or like elements or components as those of the apparatus 100 of FIG. 1A, and as such, the like elements may
5 be as described in the context of the apparatus 100 of FIG. 1A, and therefore the corresponding descriptions are omitted here.

[0065] In FIG. 2, the device 200 for the automatic ionometric composition of the sample, includes a sample intake with various options for sampling 1 from sources 202 (e.g. 112 of FIG. 1A), vacuum control valves 2 for directing a pulp (e.g. the liquid
10 sample mentioned in FIGS. 1A and 1B) to the sump 3a (e.g. the first receptacle of the sampling chamber 102 of FIG. 1A), a vacuum station 4 with various options for taking a vacuum depending on the density of the sample, a control valve 5 for supplying a rough sample 204 to a second sump 3b (e.g. the second receptacle of the sampling chamber 102 of FIG. 1A) for additional purification of the sample, control
15 valves 6 for a process water supply 210 for cleaning residues of previous sample analysis, control valves 7 for dumping to the drainage from the sumps 3a, 3b (which may also be referred to sedimentation tanks), a control valve 8 for feeding a final sample 208 to a dosing pump 9 and for blocking the flow when washing the sedimentation tanks with technical water (or process water), a conductivity sensor 10
20 (e.g. one of the one or more sensors 108 of FIG. 1A), a pH indication system 11, a pH correction system 12, a sample control sensor for pH 13, a control valve 14 for discharge into the drainage of a measuring chamber 16 (e.g. 104 of FIG. 1A), software and hardware complex (SHC) 15 (e.g. the processing unit 110 of FIG. 1A) for controlling the analysis process and controlling the preparation of the sample, and
25 an optical confirmation system analysis 17.

[0066] The device 200 may operate as follows. In an initial state, all control valves 2, 5, 6, 7, 8, 14 are in a closed position/configuration (i.e. not allowing flow there through), while the dosing pump 9 is off, and the vacuum station 4 is off.

[0067] The start of work may be initiated by the SHC 15. After checking the
30 components and controls of the device 200, the control valves 2 open at a command V1 issued by the SHC 15. The vacuum station 4 begins to create a required vacuum

and allows a slurry (pulp sample) into the sump 3a. Upon reaching a required level (e.g. determined by using limit switches not shown in FIG. 2), the command V1 is removed, e.g. by the SHC 15, and the control valves 2 close. The vacuum station 4 is then turned off. The control valves 2 allow for the vacuum station 4 to operate
5 correctly by performing the function of crossing air flow when the vacuum station 4 stops working. The SHC 15 may determine the sample settling time, taking into account the time of previous sampling and the results of the final analysis of samples.

[0068] Upon completion of the settling of the sample where the rough sample 204 has been preliminarily separated from precipitates 206 in the sump 3a, a V2 command
10 issued by the SHC 15 directs the rough sample 204 to the sump 3b for final sampling of the pulp/water sample into the measuring chamber 16. After reaching a required level in the sump 3b for the final sampling (e.g. determined by using limit switches not shown in FIG. 2), the V2 command is removed, e.g. by the SHC 15, and the control valve 5 closes to prevent further rough sample 204 into the sump 3b.

[0069] A command V4 issued by the SHC 15 then opens the control valve 8 and
15 allows the dosing pump 9 to take a sample from the final sample in the sump 3b. Depending on the set task of analyzing the sample, the dosing pump 9 fills the measuring chamber 16. At this stage, everything is ready to start the analysis.

[0070] The first stage of sample analysis is to obtain data from the sensors 10 and 13
20 (e.g. the one or more sensors 108 of FIG. 1A). These initial data are processed by the SHC 15 and the optimal analysis mode may be selected. According to the selected mode, the pH indication system 11 and the pH correction system 12 are exposed to the sample to reach a point of relevance to the set task. The point of relevance may relate to the time required for conducting one or another analysis. The need to reduce
25 the time for conducting one or another analysis may be dependent on the need to maintain a required level of specified parameters, or the need to conduct several analyzes of various samples on one device or apparatus. The process is monitored by electronic measurement with the pH sensor 13 and optically by the optical confirmation system analysis 17, The measurements are subsequently applied to an
30 analysis report. Each performed analysis adds to the measurement database and further influences the preliminary selection of the sample analysis option. Thus, by

doing so, the accuracy of determining the point of relevance in the minimum time and the number of samples analyzed may be increased.

[0071] The second stage is cleaning and preparation for the next measurement. At a command V5 from the SHC 15, the control valves 7, 14 open and the primary discharge of the contents of the sedimentation tanks 3a, 3b through a drainage 212, as well as the measuring chamber 16 through another drainage 214, is performed. Then the command V5 is removed by the SHC 15 to close the control valves 7, 14 and preparations for flushing begin. At a command V3 issued by the SHC 15, the control valves 6 open and process water is supplied to the sedimentation tanks 3a and 3b.

Upon reaching a required level in the sedimentation tanks 3a and 3b (e.g. determined by using limit switches not shown in FIG. 2), the V3 command is removed by the SHC 15 and the control valves 6 close. Next, a command V4 is issued by the SHC 15 to open the control valve 8 and enable the dosing pump 9 to fill the measuring chamber 16. Upon reaching a required level in the measuring chamber 16 (e.g. determined by using limit switches not shown in FIG. 2), the dosing pump 9 stops and the command V4 is removed by the SHC 15 to close the control valve 8. The first flushing phase is complete. The command V5 is issued from the SHC 15 to open the control valves 7, 14 to discharge the process water into the drainages 212, 214. These steps may be carried out several times, depending on the activity of the sample being measured. It is possible to add special reagents to the process water to neutralize the residual background. The reagents may be housed in reagent dosing units 18 that are in fluid communication with the measuring chamber 16. Each reagent dosing unit 18 may include a reagent dosing pump or metering pump 216 to perform dosing or microdosing of reagent to the sample in the measuring chamber 16.

[0072] The method and apparatus as described herein involve the washing and preparation of the measuring chamber and electrodes, e.g. in automatic mode (with water) and with periodic acid - for cleaning glass electrodes, that is pH electrodes, and address the challenges of electrodes overgrowth which leads to the formation of plaque on the electrode surface since the electrodes are not installed in alkaline slurry/water.

[0073] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various

changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

[Claim 1]

An apparatus for adaptively analyzing one or more physicochemical properties, the
5 apparatus comprises:

a sampling chamber configured to receive a liquid sample and to allow the liquid
sample to be separated to obtain a supernatant of the liquid sample;

a measuring chamber in fluid communication with the sampling chamber;

a dosing pump arranged between the sampling chamber and the measuring
10 chamber, wherein the dosing pump is configured to draw at least portion of the
supernatant from the sampling chamber into the measuring chamber;

one or more sensors configured to measure one or more parameters of the at least
portion of the supernatant in the measuring chamber, the one or more parameters
representative of the one or more physicochemical properties, wherein the one or more
15 sensors comprise a conductivity sensor configured to measure conductivity; and

a processing unit configured to control receipt of the liquid sample in the
sampling chamber, and activation and deactivation of the dosing pump; to receive data
for processing, wherein the data includes the one or more parameters of the at least
portion of the supernatant measured by the one or more sensors; and to analyze the
20 received data with respect to previous data, wherein the previous data includes one or
more parameters of at least portion of a supernatant obtained from a source at an earlier
point in time, wherein the processing unit is configured to process the received data using
a neural network algorithm for optimizing analysis time of the liquid sample and
determining contents of measurement environments to which the liquid sample is
25 exposed.

[Claim 2]

The apparatus as claimed in claim 1, wherein the one or more sensors further comprise a
potentiometric sensor configured to measure an electrode potential in the at least portion
30 of the supernatant in the measuring chamber.

[Claim 3]

The apparatus as claimed in claim 1 or 2, wherein the sampling chamber comprises:

a first receptacle configured to receive the liquid sample from the source and to allow the liquid sample to settle and obtain an initial supernatant of the liquid sample;

5 a second receptacle in fluid communication with the first receptacle; and

a valve arranged between the first receptacle and the second receptacle, wherein the valve is operable by the processing unit to allow at least portion of the initial supernatant to be directed from the first receptacle to the second receptacle, forming the supernatant of the liquid sample in the second receptacle.

10

[Claim 4]

The apparatus as claimed in claim 3, further comprising a vacuum station configured to create a vacuum in the first receptacle to enable the liquid sample to be transferred from the source.

15

[Claim 5]

The apparatus as claimed in claim 3 or 4, further comprising a process water inlet for each of the first receptacle and the second receptacle, wherein the process water inlet is configured to supply process water into the respective first and second receptacles and clean away residues therein.

20

[Claim 6]

The apparatus as claimed in any one of claims 1 to 5, the one or more sensors further comprise an optical sensor configured to measure an optical signal representative of a physicochemical property of the one or more physicochemical properties of the at least portion of the supernatant in the measuring chamber, wherein the processing unit is configured to receive the data further including the optical signal.

25

[Claim 7]

The apparatus as claimed in any one of claims 1 to 6, wherein the measuring chamber is made of a non-transparent material.

30

[Claim 8]

The apparatus as claimed in any one of claims 1 to 7, wherein the measuring chamber is made of an anti-abrasive material.

5

[Claim 9]

The apparatus as claimed in any one of claims 1 to 8, further comprising a drainage outlet for each of the sampling chamber and the measuring chamber, wherein the drainage outlet is configured to drain out unwanted contents in the sampling chamber and the measuring chamber.

10

[Claim 10]

The apparatus as claimed in claim 9, further comprising a plurality of further valves, each further valve of the plurality of further valves coupled to each of the dosing pump, the process water inlet, and the drainage outlet, wherein the plurality of further valves is operable by the processing unit to control flow through each of the dosing pump, the process water inlet, and the drainage outlet.

15

[Claim 11]

The apparatus as claimed in any one of claims 1 to 10, further comprising one or more reagent dosing units configured to supply one or more reagents to the measuring chamber.

20

[Claim 12]

A method for adaptively analyzing one or more physicochemical properties, the method comprises:

25

receiving a liquid sample;

allowing the liquid sample to be separated to obtain a supernatant of the liquid sample;

30

drawing at least portion of the supernatant;

measuring one or more parameters of the at least portion of the supernatant, wherein the one or more parameters comprise conductivity;

receiving data for processing by a processing unit, wherein the data includes the measured one or more parameters of the at least portion of the supernatant, the one or
5 more parameters being representative of the one or more physicochemical properties; and

processing, by the processing unit, the received data using a neural network algorithm to analyze the received data with respect to previous data that includes measured one or more parameters of at least portion of a supernatant obtained from a source at an earlier point in time, thereby optimizing analysis time of the liquid sample
10 and determining contents of measurement environments to which the liquid sample is exposed.

[Claim 13]

The method as claimed in claim 12, wherein the one or more parameters further
15 comprises an electrode potential in the at least portion of the supernatant.

[Claim 14]

The method as claimed in claim 12 or 13, wherein the step of receiving the liquid sample comprises receiving the liquid sample from the source and allowing the liquid sample to
20 settle and obtain an initial supernatant of the liquid sample; and sampling at least portion of the initial supernatant to form the supernatant of the liquid sample.

[Claim 15]

The method as claimed in claim 14, further comprising creating a vacuum to enable the
25 liquid sample to be transferred from the source.

[Claim 16]

The method as claimed in claim 14 or 15, further comprising after measuring the one or more parameters of the at least portion of the supernatant, draining out at least one of the
30 initial supernatant, the supernatant, or the at least portion of the supernatant.

[Claim 17]

The method as claimed in claim 16, further comprising after draining out at least one of the initial supernatant, the supernatant, or the at least portion of the supernatant, supplying process water to clean away residues of at least one of the initial supernatant,
5 the supernatant, or the at least portion of the supernatant.

[Claim 18]

The method as claimed in any one of claims 12 to 18 further comprising measuring one or more optical signals representative of the one or more physicochemical properties of
10 the at least portion of the supernatant, wherein the data for processing by the processing unit further includes the one or more optical signals.

[Claim 19]

The method as claimed in any one of claims 12 to 18, further comprising supplying one
15 or more reagents to the at least portion of the supernatant.