

portion of the desorption device; producing degassed sample water by removing a portion of the CO.sub.2 gas from the sample water held in the desorption chamber when the decarbonated ambient air passes through the sample water toward the top portion of the desorption device; providing the degassed sample water out of the desorption chamber via a degassed water outlet port at the bottom of the desorption device; and measuring a conductivity of the degassed sample water.

17. The method of claim 16, further comprising: detecting a flow rate of the sample water received at the desorption device; and maintaining the flow rate within a flow rate range by controlling, via one or more control processors, a water pressure in the desorption chamber.

18. The method of claim 17, wherein the water pressure in the desorption chamber is controlled by adjusting a water overflow valve to adjust a water overflow pathway via an overflow outlet port at the bottom of the desorption device.

19. The method of claim 17, wherein the water pressure in the desorption chamber is controlled by controlling an operation of a water circulation pump which adjusts a water flow rate of the degassed sample water provided from the desorption chamber via the degassed water outlet port.

20. The method of claim 16, wherein the portion of the CO.sub.2 gas removed from the sample water comprises a portion range of about 92% to about 95% of the CO.sub.2 gas, and a period of time from when the sample water enters the desorption chamber to when the degassed sample water exits the desorption chamber comprises a time range of about 45 seconds to about 90 seconds.

Description

SUMMARY

The present application discloses apparatuses and methods for detecting cation conductivity of water via an automated degas process which efficiently removes CO.sub.2 from sample water in a time period measured in seconds (e.g., about 45 seconds to about 90 seconds) rather than the 20-45 minute reboiler method time period.

A desorption device for use with detecting degassed cation conductivity is provided which includes a gas inlet port, a sample water inlet port and a desorption chamber extending between a bottom portion of the desorption device and a top portion of the desorption device. The top portion is located above the bottom portion relative to ground. The desorption chamber is configured to receive sample water that includes carbon dioxide (CO.sub.2) gas via the sample water inlet port at the top portion of the desorption device and receive decarbonated ambient air via the gas inlet port at the bottom portion of the desorption device. The desorption chamber is also configured to hold the sample water in the desorption chamber at the bottom portion of the desorption device and produce degassed sample water by removing a portion of the CO.sub.2 gas from the sample water held in the desorption chamber when the decarbonated ambient air passes through the sample water toward the top portion of the desorption device. The desorption chamber is further configured to provide a pathway, via a degassed water outlet port at the bottom of the desorption device, for the degassed sample water to flow from the desorption chamber.

An apparatus for detecting degassed cation conductivity is provided which includes a decarbonation device configured to receive ambient air and remove CO.sub.2 components from the ambient air to produce decarbonated ambient air. The apparatus also includes a desorption device comprising a desorption chamber configured to receive the decarbonated ambient air and receive sample water comprising CO.sub.2 gas. The apparatus also includes one or more control processors configured to cause the decarbonated ambient air to be provided to the sample water received into the desorption chamber and remove a portion of the CO.sub.2 gas from the sample water when the decarbonated air passes through the sample water to produce degassed sample water.

A method of detecting degassed cation conductivity is provided which includes receiving, at a desorption device, sample water comprising CO.sub.2 gas via a sample water inlet port at a top portion of the desorption

For example, sample water typically includes less harmful impurities, such as ammonium NH_4^+ ions, resulting from treated water conditioned with chemicals such as ammonia and caustic soda solution). These less harmful impurities in the sample water are removed from the sample water by passing the sample water through a resin in a cation exchanger.

The sample water also typically includes CO_2 (e.g., resulting from leaks in the water-steam circuit and the turbine condenser during the start-up period) which contributes to the conductivity of the water but contributes to the water's corrosive potential much less than the more harmful impurities.

Conventional methods for removing CO_2 from the water include using of a reboiler to heat the sample and expel the CO_2 . These reboiler methods provide useful results (i.e., removing over 90% of the CO_2 from the water) for evaluating the corrosive potential of the water. These reboiler methods are highly inefficient, however, typically requiring 20 minutes to 45 minutes to achieve these useful results, causing a time delay for loading the steam turbine which negatively impacts the efficiency of the plant.

The present application discloses apparatuses and methods for detecting cation conductivity of water via an automated degas process which efficiently removes about 92% to about 94% of the CO_2 from the sample water in a time period measured in seconds (e.g., time period of about 45 seconds to about 90 seconds) rather than the 20-45 minute reboiler method time period. Accordingly, in the 20-45 minutes of start-up time saved using the automated degas process described herein, the typical combined cycle plant generates more income from the same fuel consumed with each start-up (and even more income using typical "peak" electricity pricing). Further, the automated degas process described herein conserves more energy and reduces heat and exhaust emissions which negatively impact the environment.

Other conventional methods for removing CO_2 from the water sample include supplying pressurized bottled gasses to the water to remove the CO_2 . While these methods can remove CO_2 in less time than reboiler methods, these methods are also inefficient and hazardous. For example, the pressurized bottles are costly, use up storage space, include time to replace the bottles and can be hazardous due to the pressurized gas on site. The degas process described in the present application utilizes ambient air to produce an inert gas (i.e., decarbonated ambient air) which removes the CO_2 by passing the decarbonated ambient air through the sample water using gravity and counterflow. Accordingly, the automated degas process described herein provides useful results for evaluating the corrosive potential of the water while reducing costs, saving time and avoiding hazardous conditions.

FIG. 1 is a block diagram of an example analyzer 100 used to detect fluid conductivity according to embodiments disclosed herein. As shown in FIG. 1, the analyzer 100 includes sample inlet 102, cation exchanger 104, flow meter 106, desorption device 108, decarbonation device 110, air inlet 112, gas pump 114, circulation pump 116, overflow device 118, degassed water conductivity sensor 120, drain 122, electronics housing 124, user interface 126, water conduits 128a-128e (e.g., pipes), gas conduits 130a and 130b, and water outlet conduits 132 and 134. The sizes, shapes and locations of each of the components shown in FIG. 1 are merely exemplary. Apparatuses used to detect conductivity of sample water can include components having sizes, shapes and locations different from those shown in FIG. 1. As shown in FIG. 1, the analyzer also includes a mounting plate 140 to which components of the analyzer 100 are mounted.

Electronics housing 124 is configured to house electronic and processing components used to control operation of the components and to communicate between the components described herein. Electronic and processing components include, for example, one or more processors 125 and other components (not shown) such as memory, circuitry, wires, buses, transmitters, receivers and network interfaces. The electronic and processing components may be configured to communicate (wired or wirelessly) with components of analyzer 100. Additionally one or more electronic and processing components, such as one or more additional control processors (not shown), can be located at one or more of the components of the analyzer and configured to communicate with the electronic and processing components housed at electronics housing 124. The one or more control processors 125 are configured to process instructions (e.g., from user input and predefined programmed instructions).

As shown in FIG. 1, user interface 124 (e.g., touch screen display) is disposed at electronics housing 124. User interface 124 may be disposed at a location separate from electronics housing. User interface 124 is used to display operating conditions (e.g., conductivity measurements, flow rate, water temperature, ambient

air temperature and water pressure) of analyzer 100. User interface 124 is also configured to receive user input for selecting parameters (e.g., numerical values) for setting operating conditions of components of the analyzer.

Arrows are used in FIG. 1 to illustrate the flow of sample water and gas (e.g., decarbonated air) through components of the analyzer 100. As shown in FIG. 1, sample water flows from sample inlet 102 to cation exchanger 104 via water conduit 128a. The sample water received at cation exchanger 104 is typically treated water (i.e., water which has been conditioned with chemicals, such as ammonia and/or caustic soda solution). The treated water includes impurities (e.g., ammonium NH_4^+ ions) which contribute to the conductivity of the water, but contribute much less to the corrosive potential of the water than other more harmful impurities, such as acid producing anions such as chlorides and acetates.

The cation exchanger 104 includes specific conductivity sensor 104a, cation conductivity sensor 104b and water conduit 104c. As the sample water passes through conduit 104c, sample water flows (indicated by the left arrow in the cation exchanger 104) to a section of the cation exchanger 104 where the specific conductivity sensor 104a detects the total dissolved solids in the sample water.

Sample water also flows (indicated by the right arrow in the cation exchanger 104) to a section of the cation exchanger 104 having a resin 104d which removes the ions (e.g., ammonium NH_4^+ ions) from the treated sample water and where the cation conductivity sensor 104b detects the cation conductivity of the treated sample water. That is, the cation conductivity sensor 104b detects the cation conductivity of the sample water after the less harmful impurities are removed from the sample water to more accurately determine the water conductivity due to the presence of the more harmful impurities (e.g., acid producing anions such as chlorides and acetates) in the sample water.

The sample water exiting the cation exchanger 104 flows to flow meter 106 which determines a flow rate of the sample water passing through the flow meter 106 and supplied to desorption device 108. A pH value of the sample water exiting the cation exchanger 104 is determined based on the detected specific conductivity and the detected cation conductivity of the water.

In addition to the ions (e.g., ammonium NH_4^+ ions) removed by the cation exchanger, the sample water also includes other impurities (i.e., organic components) which contribute to water conductivity but contribute much less to the corrosive potential of the water than the more harmful impurities. For example, air can penetrate (e.g., via leaks in the water-steam circuit and via the turbine condenser during a turbine start-up period) the steam turbine system. While oxygen and nitrogen and other trace gases in the air physically dissolve and do not form ions or contribute to water conductivity, CO_2 chemically dissolves into ions in the circulating water and contributes to the water conductivity.

The chemical reactions of CO_2 in the water are shown by the following equations:

$\text{CO}_2 + 2\text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{H}_3\text{O}^+$ (pK=6.3) Equation 1
 $\text{HCO}_3^- + 2\text{H}_2\text{O} \rightleftharpoons \text{CO}_3^{2-} + \text{H}_3\text{O}^+$ (pK=10.3) Equation 2
 where pK is the logarithmic value of the dissociation constant K. The chemical equilibrium state of the chemical reactions is pH dependent. At a pH value of 5.0, about 94% of the CO_2 in the water exists as CO_2 gas and about 6% of the CO_2 exists as carbonate ions HCO_3^- . The pH value of the water exiting the cation exchanger 104 is typically in the range of about 5.5 to about 6.0. Accordingly, the CO_2 content of the sample water exiting the cation exchanger 104 is primarily CO_2 gas and the bicarbonate ion, CO_3^{2-} , is miniscule, which renders the CO_2 to be much less harmful to corrosion than the ions of salt containing components. Because CO_2 contributes to the conductivity of the water, however, the CO_2 causes artificially high conductivity measurements for evaluating corroding anionic impurities of the water.

To provide more accurate conductivity measurements for detecting the presence of the harmful impurities contributing to the corrosive potential of the water, the CO_2 is removed from the sample water through an efficient degas procedure. For example, referring again to FIG. 1, analyzer 100 includes components (e.g., degas assembly components) configured to remove a large portion of the CO_2 (e.g., a range of about 92% to about 95% of the CO_2) from the sample water in a time period ranging from about 45 seconds to about 90 seconds.

As shown in FIG. 1, exemplary degas assembly components include desorption device 108, decarbonation

