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(54) Title: REVERSE POLARITY CLEANING AND ELECTRONIC FLOW CONTROL SYSTEMS FOR LOW INTERVENTION ELECTROLYTIC CHEMICAL GENERATORS

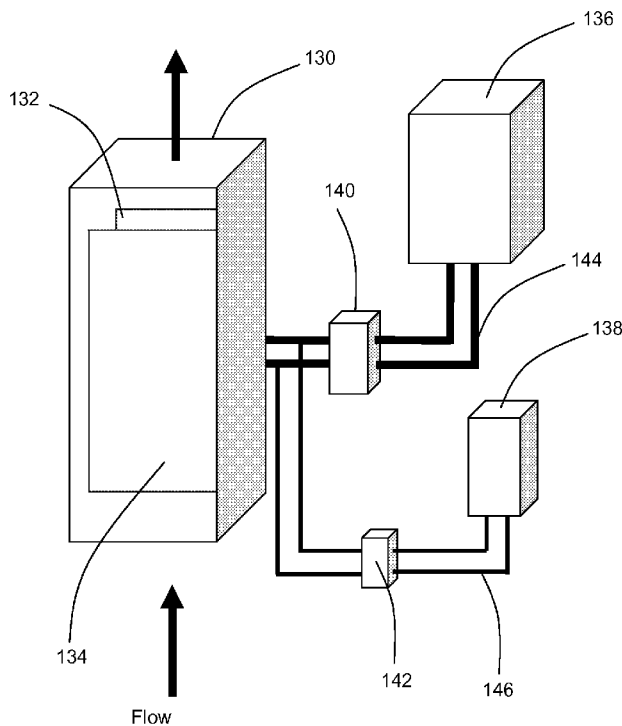


FIG. 2

(57) Abstract: Method and apparatus for a low maintenance, high reliability on-site electrolytic generator incorporating automatic cell monitoring for contaminant film buildup, as well as automatically removing or cleaning the contaminant film. This method and apparatus preferably does not require human intervention to clean. For high current density cells, cleaning is preferably performed by reversing the polarity of the electrodes and applying a lower current density to the electrodes. A second lower current density power supply may be used for reverse polarity cleaning. Electrolyte flow is preferably monitored and automatically adjusted.

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**REVERSE POLARITY CLEANING AND ELECTRONIC FLOW CONTROL SYSTEMS FOR
LOW INTERVENTION ELECTROLYTIC CHEMICAL GENERATORS**

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of filing of U.S. Provisional Patent Application Serial No. 61/056,718, entitled "Reverse Polarity Cleaning for High Current Density Electrolytic Cells," filed on May 28, 2008. This application is also a continuation-in-part application of U.S. Patent Application Serial No. 11/946,772, entitled "Low Maintenance On-Site Generator", filed on November 28, 2007, which application claims priority to and the benefit of filing of U.S. Provisional Patent Application Serial No. 60/867,557, entitled "Low Maintenance On-Site Generator", filed on November 28, 2006. The specification and claims of all of these applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The present invention relates to an electrolytic on-site generator which is nearly free of maintenance.

Background Art:

Note that the following discussion refers to a number of publications and references. Discussion of such publications herein is given for more complete background of the scientific principles and is not to be construed as an admission that such publications are prior art for patentability determination purposes.

Electrolytic technologies utilizing dimensionally stable anodes have been developed to produce mixed-oxidants and sodium hypochlorite solutions from a sodium chloride brine solution. Dimensionally stable anodes are described in U.S. Patent No. 3,234,110 to Beer, entitled "Electrode and Method of Making Same," wherein a noble metal coating is applied over a titanium substrate. Electrolytic cells have had wide use for the production of chlorine and mixed oxidants for the disinfection of water. Some of the simplest electrolytic cells are described in

U.S. Patent No. 4,761,208, entitled "Electrolytic Method and Cell for Sterilizing Water", and U.S. Patent No. 5,316,740, entitled "Electrolytic Cell for Generating Sterilizing Solutions Having Increased Ozone Content."

Electrolytic cells come in two varieties. The first category comprises divided cells that utilize membranes to maintain complete separation of the anode and cathode products in the cells. The second category comprises undivided cells that do not utilize membranes, but that also do not suffer nearly as much from issues associated with membrane fouling. However, it is well accepted that one of the major failure mechanisms of undivided electrolytic cells is the buildup of unwanted films on the surfaces of the electrodes. The source of these contaminants is typically either from the feed water to the on-site generation process or contaminants in the salt that is used to produce the brine solution feeding the system. Typically these unwanted films consist of manganese, calcium carbonate, or other unwanted substances. If buildup of these films is not controlled or they are not removed on a fairly regular basis, the electrolytic cells will lose operating efficiency and will eventually catastrophically fail (due to localized high current density, electrical arcing or some other event). Typically, manufacturers protect against this type of buildup by incorporating a water softener on the feed water to the system to prevent these contaminants from ever entering the electrolytic cell. However, these contaminants will enter the process over time from contaminants in the salt used to make the brine. High quality salt is typically specified to minimize the incidence of cell cleaning operations. Processes are well known in the art for purifying salt to specification levels that will avoid contaminants from entering the cell. However, these salt cleaning processes, although mandatory for effective operation of divided cells, are considered too complicated for smaller on-site generation processes that utilize undivided cells.

U.S. Patent Application Serial No. 11/287,531, which is incorporated herein by reference, is directed to a carbonate detector and describes one possible means of monitoring an electrolytic cell for internal film buildup. Other possible means for monitoring carbonate buildup in cells that utilize constant current control schemes is by monitoring the rate of brine flow to the cell. As brine flow increases, it is usually, but not always, indicative of carbonate formation on the cathode electrode which creates electrical resistance in the cell. Other than these methods and/or visual inspection of the internal workings of a cell, there currently is not an adequate method of monitoring the internal status of the buildup on an electrolytic cell.

The current accepted method of cleaning an electrolytic cell is to flush it with an acid (often muriatic or hydrochloric acid) to remove any deposits which have formed. Typically, manufacturers recommend performing this action on a regular basis, at least yearly, but sometimes as often as on a monthly basis. Thus there is a need for a more reliable method for insuring cleanliness of the electrolytic cell is to perform a cleaning process on an automated basis that does not require the use of a separate supply of consumables such as muriatic or hydrochloric acid, and that does not require operator intervention.

U.S. Patent No. 5,853,562 to Eki, et al. entitled "Method and Apparatus for Electrolyzing Water" describes a process for reversing polarity on the electrodes in a membraneless electrolytic cell for the purpose of removing carbonate scale and extending the life of the electrolytic cell. This method of electrolytic cell cleaning is routinely used in flow through electrolytic chlorinators that convert sodium chloride salt in swimming pool water to chlorine via electrolysis. However, currently used flow through electrolytic cells are constructed of electrodes (anode and cathode) that both have common catalytic coatings. As electrical polarity is changed, the old cathode becomes the anode, and the anode becomes the cathode. Special catalytic coatings have been developed for these applications. For instance, Eltech Corporation has developed the EC-600 coating specifically for the swimming pool chlorination market. Sodium chloride is typically added to the pool water raising the total dissolved solids (TDS) content to approximately 4 to 5 grams per liter. At these TDS values, the current density in the swimming pool electrolytic cells is relatively low. The special anode coatings for pool applications are designed to tolerate these low current densities for extended periods with polarity applied in either direction. However, most dimensionally stable anodes for chlorine production in membraneless electrolytic cells producing chlorine at 8 gram per liter (8,000 mg/L) concentration of free available chlorine (FAC) cannot tolerate high current densities (greater than approximately 1 amp per square inch) in reverse polarity mode. Thus, although simply reversing the polarity works for low current density electrolytic cells, it will not work for electrolytic cells which normally operate at a high current density, since the anode will be damaged if high current density is applied during the reverse polarity cleaning operation.

One of the other maintenance items for electrolytic generators is the requirement that operators occasionally measure and set water flow into the system. The flow through the generator can vary greatly with incoming and outgoing water pressure and/or contaminant

buildup in the system or electrolytic cells. Typically, measurements are made with either flowmeters or with timed volume measurements, and adjustments to the flow are performed with manual valves. Keeping the electrolytic generator operating within flow specifications is important, as it ensures reliable long term operation the generator within its efficiency specifications.

SUMMARY OF THE INVENTION (DISCLOSURE OF THE INVENTION)

The present invention is a method for operating an electrolytic cell, the method comprising the steps of supplying brine to an electrolytic cell, producing one or more oxidants in the electrolytic cell, detecting a level of contaminant buildup, automatically stopping the brine supply after an upper contaminant threshold is detected, automatically cleaning the electrolytic cell, thereby reducing contaminants in the electrolytic cell, and automatically continuing to produce the one or more oxidants after a lower contaminant threshold is detected. The cleaning step preferably comprises providing brine to an acid generating electrolytic cell, generating an acid in the acid generating electrolytic cell, and introducing the acid into the electrolytic cell. The acid preferably comprises muriatic acid or hydrochloric acid. The method preferably further comprises the step of diluting the brine. The detecting step preferably comprises utilizing a carbonate detector. The detecting step preferably comprises measuring the rate of brine consumption in the electrolytic cell, optionally by measuring a quantity selected from the group consisting of flow meter output, temperature of the electrolytic cell, brine pump velocity, and incoming water flow rate. The method preferably further comprises comparing the rate of brine consumption to the rate of brine consumption in a clean electrolytic cell. The cleaning step optionally comprises using an ultrasonic device and/or using a magnetically actuated mechanical electrode cleaning device, or reversing the polarity of electrodes in the electrolytic cell, thereby lowering the pH at a cathode.

The present invention is also an apparatus for producing an oxidant, the apparatus comprising a brine supply, an electrolytic cell, an acid supply, and a control system for automatically introducing acid from the acid supply into the electrolytic cell. The acid supply preferably comprises a second electrolytic cell, and the brine supply preferably provides brine to the second electrolytic cell during a cleaning cycle. The apparatus preferably further comprises a variable speed brine pump, a carbonate detector, one or more thermowells for

measuring a temperature of said electrolytic cell, and/or one or more flowmeters for measuring the brine flow rate.

The present invention is also an apparatus for producing an oxidant, the apparatus comprising a brine supply, an electrolytic cell, a cleaning mechanism in the electrolytic cell, and a control system for automatically activating the cleaning mechanism. The cleaning mechanism preferably is selected from the group consisting of ultrasonic horn, magnetically actuated electrode mechanical cleaning device, and acidic solution at a cathode surface. The apparatus preferably further comprises a device selected from the group consisting of a carbonate detector, at least one thermowell for measuring a temperature of said electrolytic cell, and a flowmeter for measuring a brine flow rate.

The present invention is also a method for cleaning an electrolytic cell comprising electrodes, the method comprising the steps of reversing polarities of two or more of the electrodes and providing a cleaning current density to the electrodes which is lower than an operational current density used during normal operation of the electrolytic cell. During normal operation the electrolytic cell preferably produces a concentration of free available chlorine greater than approximately four grams per liter, more preferably greater than approximately five grams per liter, and most preferably approximately eight grams per liter. The operational current density is preferably greater than approximately one amp per square inch. The cleaning current density is preferably less than approximately 20% of the operational current density, and more preferably between approximately 10% and approximately 15% of the operational current density. The providing step is preferably performed for less than approximately thirty minutes, and more preferably for between approximately five minutes and approximately ten minutes. The reversing step optionally comprises using at least one power supply relay or other switching device. The operational current density is preferably provided by an operational power supply and the cleaning current density is preferably provided by a separate cleaning power supply. The power producing capacity of the cleaning power supply is preferably smaller than the power producing capacity of the operational power supply. The method preferably further comprises the step of monitoring a flow rate of electrolyte through the electrolytic cell. The monitoring step is preferably performed using a flowmeter, a rotameter, or a pressure transducer, or monitoring a temperature difference across the electrolytic cell via a first thermocouple or thermowell

disposed at an inlet of the electrolytic cell a second thermocouple or thermowell disposed at an outlet of the electrolytic cell. The method preferably further comprises the step of automatically adjusting the flow rate, and preferably further comprises the step of initiating a cleaning cycle at a predetermined flow rate.

The present invention is also method for cleaning an electrolytic cell comprising electrodes, the method comprising the steps of reversing polarities of two or more of the electrodes and providing a cleaning voltage potential difference to the electrodes which is lower than an operational voltage potential difference used during normal operation of the electrolytic cell. During normal operation the electrolytic cell preferably produces a concentration of free available chlorine greater than approximately five grams per liter. The providing step is preferably performed for a time between approximately five minutes and approximately ten minutes. The reversing step preferably comprises using at least one power supply relay or other switching device. The operational voltage potential difference is preferably provided by an operational power supply and the cleaning voltage potential difference is preferably provided by a separate cleaning power supply. The method preferably further comprises the steps of monitoring a flow rate of electrolyte through the electrolytic cell and automatically adjusting the flow rate.

The present invention is also an apparatus for producing electrolytic products, the apparatus comprising an electrolytic cell comprising electrodes; a first power supply for providing a first current density to the electrodes, a second power supply for providing a second current density to the electrodes, the second power supply having an opposite polarity to the first power supply, wherein the second current density is smaller than the first current density. The electrolytic cell preferably produces a concentration of free available chlorine greater than approximately five grams per liter. The second current density is preferably between approximately 10% and approximately 15% of the first current density. The apparatus preferably further comprises at least one power supply relay or other switching device, and preferably comprises a flow monitoring device for monitoring a flow rate of electrolyte through the electrolytic cell. The flow monitoring device is preferably selected from the group consisting of a flowmeter, a rotameter, a pressure transducer, a pair of thermocouples, and a pair of thermowells. If a pair of thermocouples or thermowells is used, one thermocouple or thermowell is preferably disposed at an inlet of the electrolytic cell and

another thermocouple or thermowell is preferably disposed at an outlet of the electrolytic cell. The apparatus preferably further comprises an electronically operated valve for adjusting the flow rate.

Objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawings, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawing, which is incorporated into and form a part of the specification, illustrates an embodiment of the present invention and, together with the description, serves to explain the principles of the invention. The drawing is only for the purpose of illustrating a preferred embodiment of the invention and is not to be construed as limiting the invention. In the drawings:

FIG. 1 is a diagram of one embodiment of a low maintenance on-site generator unit.

FIG. 2 is a schematic of a reverse polarity system for electrolytic cell cleaning.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(BEST MODES FOR CARRYING OUT THE INVENTION)

Embodiments of the present invention are methods and devices whereby an on-site generator electrolytic cell is preferably monitored automatically for buildup of contaminants on the electrode surfaces, and when those contaminants are detected, the electrolytic cell is cleaned automatically (i.e, without operator intervention), thereby providing a simple, low cost, and reliable process for achieving a highly reliable, low maintenance, on-site generator which does not require the typical operator intervention and/or auxiliary equipment (such as a water softener) now required for long life of electrolytic cells.

The internal status of the electrolytic cells can be monitored automatically by monitoring cell inputs and performance. It is known that how much brine a cell consumes is dependent on

the amount and type of film buildup on that given cell. If brine flow is continuously monitored, any dramatic change in brine flow to reach a given current at a given voltage is indicative of a potential problem with film buildup within a cell. The invention preferably monitors the flow characteristics of the brine, incoming water, temperature, etc., to determine whether or not there has been contaminant buildup within the electrolytic cell. When potential film buildup is detected in the cell by the control system, the cell is preferably automatically acid washed.

A carbonate detector integrated with an electrolytic cell, automatic acid washing, and device controls may be utilized. A separate electrolytic cell from the one used to create the mixed oxidant or sodium hypochlorite is preferably used to create the acid on site and on demand and to provide the acid for removing of contaminants in the electrolytic cell used for creating the sodium hypochlorite or mixed oxidants. Alternatively a reservoir is used to store concentrated acid onsite for cleaning the cell, and monitoring that acid reservoir and alarming operators when that acid reservoir would need to be refilled, as well as optionally diluting the acid to a desired concentration prior to washing the cell. An ultrasonic cleaning methodology for automatically removing unwanted contaminants when the contaminants are detected by the methods described above may also be integrated into the present invention.

An embodiment of the present invention is shown in FIG. 1. All of the components of this device are preferably mounted to back plate **15**. The controls and power supplies for all the separate components shown in this embodiment are all preferably contained within control box **5**, but may alternatively be located wherever it is convenient, preferably as long as there are master controls for the overall operation of the apparatus.

Control box **5** preferably shows the status of the unit via display **10**, and the master controls as well as electrical power and/or component signals are preferably carried via electrical connections **50** between control box **5** and the various individual components. Water preferably enters the system through water entrance pipe **30**, and brine preferably enters the system through brine entrance pipe **25**. Brine, preferably stored in a saturated brine silo or tank, is preferably pumped via variable speed brine pump **20**, which is preferably controlled and powered by electrical connection **50**. The brine then preferably passes through flow meter **35**, which can be electrically monitored via electrical connection **50**. The control system can control the flow rate of the brine by increasing the speed of variable speed brine pump **20**.

When the electrolytic generator is in normal operation mode and is at target current and target voltages, the total flow through the electrolytic cell **55** can be monitored, for example by a flowmeter, rotameter, or pressure transducer, or by monitoring the change in temperature across the electrolytic cell **55** by monitoring inlet thermowell **65** and exit thermowell **70**. When control box **5** determines that flow is off target, for example in response to fluctuations in incoming pressure and/or flow to the electrolytic generator, it preferably automatically adjusts flow by changing electronically controlled cell inlet valve **6**. In this way, the cell can always operate near target flow levels and will not routinely require measurement or adjustment of incoming flows.

Data from any of the following sources (or combinations of data from any of these sources) is preferably used to determine the volumetric flow rate of brine: flow meter **35**, carbonate detector **60**, electrolytic cell **55**, acid generating electrolytic cell **45**, and/or thermowells **65**, **70**. Valve **40** can direct flow either to electrolytic cell **55** or to acid generating electrolytic cell **45**. Valve **40** typically flows an electrolyte comprising diluted brine (as both the concentrated brine and water inflows have preferably been plumbed together and the brine has been diluted before it reaches valve **40**) to electrolytic cell **55**. In this standard operating configuration, the system produces, for example, mixed oxidants or sodium hypochlorite.

As contaminants build up on carbonate detector **60**, which may be located elsewhere according to the present invention, carbonate detector **60** sends a series of signals to control box **5**, preferably via electrical connections **50**, which indicate whether or not a contaminant film is building up on electrolytic cell **55**. When carbonate detector **60** indicates that there is contaminant film, control box **5** preferably begins an acid cleaning cycle in the device, wherein valve **40** is actuated via electrical connection **50** to force diluted brine through acid generating cell **45**, which is also preferably energized by control box **5** via electrical connections **50**. The system preferably runs brine pump **20** to flow at a rate (as measured by flow meters **35**) which has been optimized for optimal acid creation in acid generating electrolytic cell **45**. In this embodiment, the acid created in acid generation cell **45** preferably flows through electrolytic cell **55**, where it preferably cleans the contaminants, then flows through carbonate detector **60**. The system preferably runs in this acid cleaning mode until carbonate detector **60** sends a signal to control box **5** indicating that the system is clean and can begin running again in standard mixed oxidant or sodium hypochlorite production mode. The acid used to

clean electrolytic cell **55** is preferably dumped to a separate waste drain after flowing through carbonate detector **60** instead of dumping it to the oxidant storage tank. Electrolytic cell **55** may optionally be cleaned with an ultrasonic horn and/or a magnetically actuated electrode mechanical cleaning apparatus in addition to or in place of using an acid generating cell.

In an alternative embodiment, concentrated acid is stored in a reservoir. During the acid cleaning cycle, control box **5** preferably activates a pump or valve to allow flow of the acid to electrolytic cell **55**. The reservoir is preferably large enough to accommodate many different acid wash cycles. Some of that acid may potentially be diluted with standard incoming water to clean electrolytic cell **55**.

If carbonate detector **60** (or any other contaminant detecting component) is not used, electrolytic cell **55** preferably may be cleaned on a predetermined cleaning schedule to ensure contaminants do not ruin electrolytic cell **55**. Typically this cleaning schedule would be based upon the number of hours that the electrolytic cell had been running since the last cleaning was completed, and is preferably frequent enough to ensure that there is no excessive contaminant buildup on the electrolytic cell.

The rate of brine consumption may optionally be used to determine the presence of contaminants in electrolytic cell **55**. In normal operation in a clean cell, the rate of brine consumption is steady and measurable. As carbonate scale builds up within electrolytic cell **55**, the carbonate layer acts as an electrical insulator between the anode and cathode within electrolytic cell **55**. To compensate for this insulating effect, and to maintain the amperage within electrolytic cell **55**, the rate of brine consumption increases to increase the conductivity within electrolytic cell **55**. This increased rate of brine consumption is compared to the normal rate of brine consumption. Flow through electrolytic cell **55** can also be used to measure contaminant buildup within electrolytic cell **55**. Flow can be measured indirectly by measuring the temperature rise through electrolytic cell **55**, for example by comparing the temperature difference between two thermocouples or inlet thermowell **65** and cell discharge thermowell **70**. When carbonate buildup is detected by any of these means, electrolytic cell **55** can be cleaned by any of the methods or components described above. Brine consumption may be measured using brine flow rate, tachometer rates of brine pump **20**, or incoming water flow rates.

In addition to (or instead of) the cleaning methods described above, the electrolytic cell may optionally be cleaned by reversing the polarity of the electrodes in electrolytic cell, while flowing electrolyte through the electrolytic cell or not, and preferably for a very short duration. Reversing the polarity of the electrodes, preferably at low current densities, lowers the pH at the cathode, which dissolves and removes the contaminants. However, the dimensionally stable anode in the chlorine (4 to 8 gm/L) producing electrolytic cell described herein typically operates well at high current densities (up to 2 amps per square inch), but would fail quickly if polarity were reversed at the same current density. Thus it is preferable to use a separate power source at lower current density and/or lower plate to plate voltages to clean the cell in reverse polarity mode, which is only operated when the normal chlorine production operational mode is in standby, so that the primary anode coating remains undamaged. Under these conditions, cleaning cycles of less than 30 minutes can be achieved, preferably ranging between approximately 5 minutes and 10 minutes. Industry experience indicates that cell cleaning intervals of less than a week would represent an unfavorable situation where the feed water to the electrolytic cell, or the salt used to make the brine solution, would typically be poor quality. Intervals between cleaning of greater than one week are clearly the industry norm. Under the worst case condition of cleaning once per week, the loss of system duty cycle (production operation mode) would still be negligible.

In any embodiment using reverse polarity to clean the electrolytic cell, both the anode and cathode surfaces of both primary and bi-polar electrodes are preferably coated with an appropriate dimensionally stable anode coating.

FIG. 2 is a schematic of an embodiment of a system for implementing reverse polarity cleaning. Electrolytic cell **130** comprises anode **134** and cathode **132** with electrolyte flowing in at the bottom and oxidant flowing out at the top of the cell. In normal operation, electrolytic cell **130** has electrical energy applied to anode **134** and cathode **132** via main power supply **136**. Periodically, electrolytic cell **130** will be cleaned by reversing the polarity on anode **134** and cathode **132**, effectively making anode **134** the cathode, and cathode **132** the anode. In the normal mode of production where the system is producing a chlorine based disinfectant, the current density on anode **134** is preferably between approximately 1 and 2 amps per square inch. To avoid damage to anode **134** during the reverse polarity cleaning step, the current density is preferably less than approximately twenty percent of the normal operating

current density range, and more preferably between about 10% and 15% of the normal operating current density range. Because the reverse polarity cleaning operation operates at much lower power settings, power is preferably supplied by cleaning power supply **138**, which can be much smaller than main power supply **136**. Power from main power supply **136** is transferred to electrolytic cell **130** preferably via main power cables **144**. Power from cleaning power supply **138** is transferred to electrolytic cell **130** preferably via cleaning power cables **146**. The power supplies are preferably isolated via main power supply relay **140** and cleaning power supply relay **142**. In normal operation when chlorine is being produced within electrolytic cell **130**, main power supply **136** is energized and main power supply relay **140** is closed. To avoid backflow of current to cleaning power supply **138** with the wrong polarity, cleaning power supply relay **142** is open. Likewise, when electrolytic cell **130** is operating in cleaning mode, cleaning power supply **138** is energized, main power supply **136** is de-energized, main power supply relay **140** is open, and cleaning power supply relay **142** is closed. By utilizing less current density and/or lower potentials on anode **134** during the short cleaning cycle, damage to anode **134** or cathode **132** due to the cleaning cycle is negligible.

An alternative embodiment to the one shown in Fig 2 uses the main power supply **136** to provide power for normal operation as well as the cleaning cycles. This approach preferably employs the use of power supply relays **142** or other switching devices to reverse the polarity. Typically this approach requires the electrolytic cell brine concentrations during the cleaning cycle to be much less than in normal operation. With this approach, however, it is still preferable that the cleaning cycle be performed at lower current densities and/or lower potentials for short periods of time.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover all such modifications and equivalents. The entire disclosures of all patents and publications cited above are hereby incorporated by reference.

CLAIMS

What is claimed is:

1. A method for cleaning an electrolytic cell comprising electrodes, the method comprising the steps of:
 - reversing polarities of two or more of the electrodes; and
 - providing a cleaning current density to the electrodes which is lower than an operational current density used during normal operation of the electrolytic cell.
2. The method of claim 1 wherein during normal operation the electrolytic cell produces a concentration of free available chlorine greater than approximately four grams per liter.
3. The method of claim 2 wherein during normal operation the electrolytic cell produces a concentration of free available chlorine greater than approximately five grams per liter.
4. The method of claim 3 wherein the concentration of free available chlorine is approximately eight grams per liter.
5. The method of claim 1 wherein the operational current density is greater than approximately one amp per square inch.
6. The method of claim 1 wherein the cleaning current density is less than approximately 20% of the operational current density.
7. The method of claim 6 wherein the cleaning current density is between approximately 10% and approximately 15% of the operational current density.

8. The method of claim 1 wherein the providing step is performed for less than approximately thirty minutes.
9. The method of claim 8 wherein the providing step is performed for between approximately five minutes and approximately ten minutes.
10. The method of claim 1 wherein the reversing step comprises using at least one power supply relay or other switching device.
11. The method of claim 1 wherein the operational current density is provided by an operational power supply and the cleaning current density is provided by a separate cleaning power supply.
12. The method of claim 11 wherein a power producing capacity of the cleaning power supply is smaller than a power producing capacity of the operational power supply.
13. The method of claim 1 further comprising the step of monitoring a flow rate of electrolyte through the electrolytic cell.
14. The method of claim 13 wherein the monitoring step is performed using a flowmeter, a rotameter, or a pressure transducer, or monitoring a temperature difference across the electrolytic cell via a first thermocouple or thermowell disposed at an inlet of the electrolytic cell a second thermocouple or thermowell disposed at an outlet of the electrolytic cell.
15. The method of claim 13 further comprising the step of automatically adjusting the flow rate.
16. The method of claim 13 further comprising the step of initiating a cleaning cycle at a predetermined flow rate.

17. A method for cleaning an electrolytic cell comprising electrodes, the method comprising the steps of:

reversing polarities of two or more of the electrodes; and

providing a cleaning voltage potential difference to the electrodes

which is lower than an operational voltage potential difference used during normal operation of the electrolytic cell.

18. The method of claim 17 wherein during normal operation the electrolytic cell produces a concentration of free available chlorine greater than approximately five grams per liter.

19. The method of claim 17 wherein the providing step is performed for a time between approximately five minutes and approximately ten minutes.

20. The method of claim 17 wherein the reversing step comprises using at least one power supply relay or other switching device.

21. The method of claim 17 wherein the operational voltage potential difference is provided by an operational power supply and the cleaning voltage potential difference is provided by a separate cleaning power supply.

22. The method of claim 17 further comprising the steps of monitoring a flow rate of electrolyte through the electrolytic cell and automatically adjusting the flow rate.

23. An apparatus for producing electrolytic products, the apparatus comprising:
an electrolytic cell comprising electrodes;
a first power supply for providing a first current density to said electrodes;
a second power supply for providing a second current density to said electrodes, said second power supply having an opposite polarity to said first power supply;
wherein the second current density is smaller than the first current density.
24. The apparatus of claim 23 wherein said electrolytic cell produces a concentration of free available chlorine greater than approximately five grams per liter.
25. The apparatus of claim 23 wherein the second current density is between approximately 10% and approximately 15% of the first current density.
26. The apparatus of claim 23 further comprising at least one power supply relay or other switching device.
27. The apparatus of claim 23 further comprising a flow monitoring device for monitoring a flow rate of electrolyte through said electrolytic cell.
28. The apparatus of claim 27 wherein said flow monitoring device is selected from the group consisting of a flowmeter, a rotameter, a pressure transducer, a pair of thermocouples, and a pair of thermowells.
29. The apparatus of claim 28 wherein one thermocouple or thermowell is disposed at an inlet of said electrolytic cell and another thermocouple or thermowell is disposed at an outlet of said electrolytic cell.
30. The apparatus of claim 27 further comprising an electronically operated valve for adjusting the flow rate.

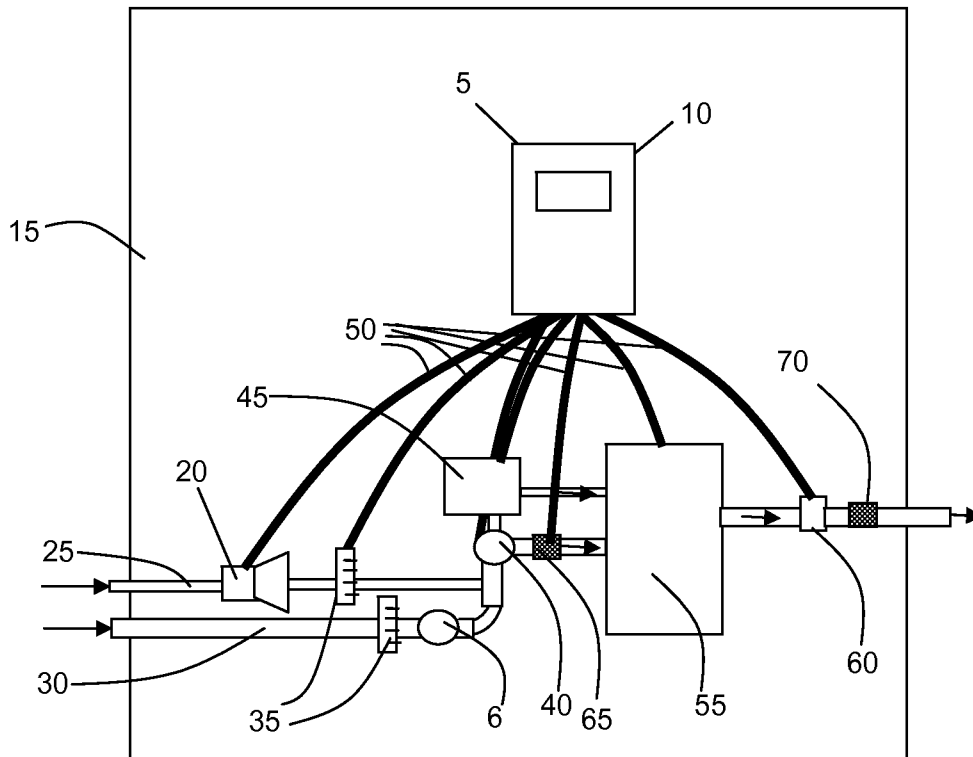


FIG. 1

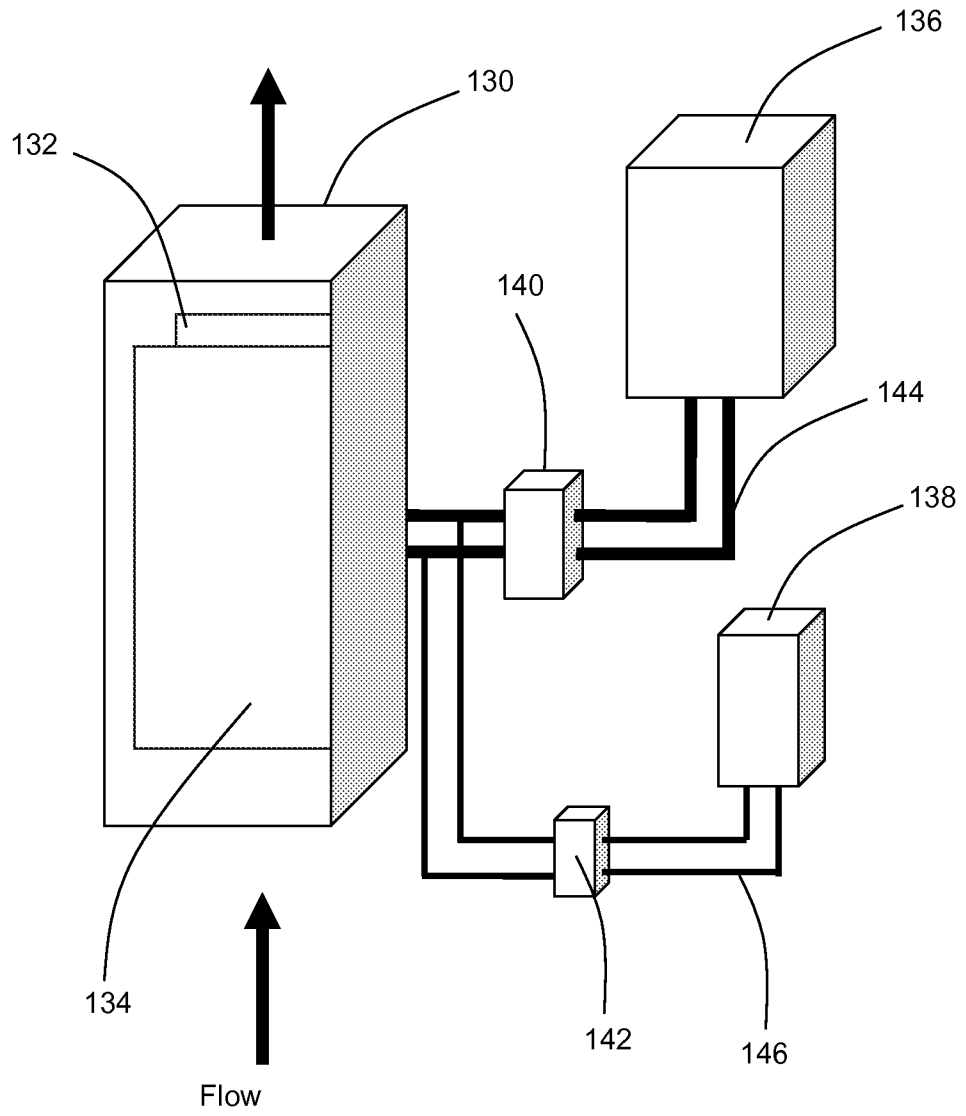


FIG. 2