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(54) **ELECTROLYTE CIRCULATION SYSTEM, CORRESPONDING CONTROL METHOD, AND STORAGE MEDIUM**

(57) The present invention relates to an electrolyte circulation system for an electrolysis system, comprising: a primary gas-liquid separator; a pressure reduction device connected to the primary gas-liquid separator that performs primary gas-liquid separation of a desired gas to reduce pressure; a secondary gas-liquid separator connected to the pressure reduction device to receive an electrolyte and perform secondary gas-liquid separation thereon; a pressurization device connected to the secondary gas-liquid separator to pressurize the electrolyte after secondary gas-liquid separation; and a mixing supply device configured to receive

and mix the pressurized electrolyte and another electrolyte from another electrode and supply the mixed electrolyte back to the electrolysis system. The present invention further relates to an electrolysis system comprising, on at least one side corresponding to at least one of the first and second gases produced by the electrolysis system, the electrolyte circulation system as described above at the respective electrodes. The present invention further relates to a corresponding control method and a storage medium. With the present invention, the safety of electrolysis can be enhanced.

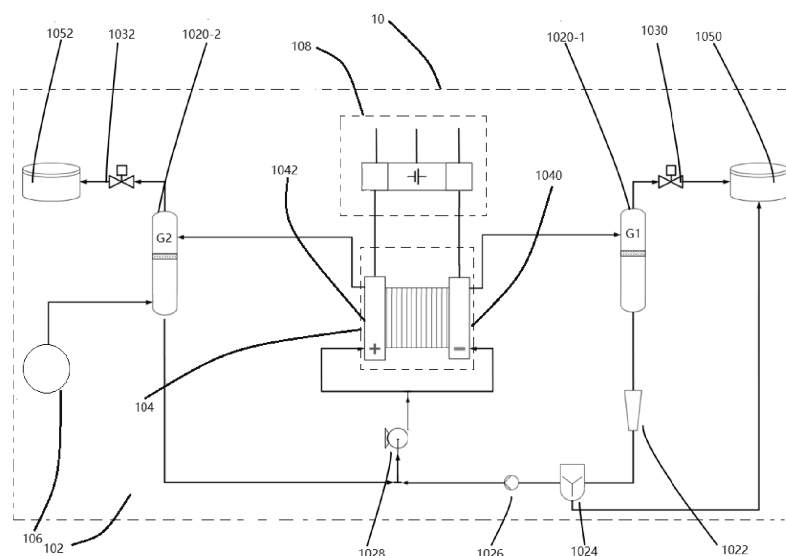


FIG. 1

Description

Technical Field

[0001] This application generally relates to an electrolyte circulation system, and also to a control method for such an electrolyte system and a related storage medium implementing the relevant control method.

Background

[0002] It is well known that in the field of electrolysis, electrolysis systems such as electrolytic cells are typically used to perform electrolysis operations. These electrolysis operations often optionally utilize an electrolyte to produce specific gaseous substances.

[0003] For example, such electrolysis operations generate cathode gas products or anode gas products at the cathode or anode of the electrolysis system, respectively, with the aid of an electrolyte. For instance, hydrogen (anode gas product) and oxygen (cathode gas product) are produced using an electrolyte such as an aqueous solution containing specific salts.

[0004] It is known that in electrolysis systems such as those described above, the anode electrolyte carries the anode gas product into an anode gas-liquid separator, and/or the cathode electrolyte carries the cathode gas product into a cathode gas-liquid separator to obtain the desired anode gas product and cathode gas product, respectively.

[0005] To achieve efficient utilization of the electrolyte, the electrolyte separated from the cathode gas-liquid separator and the electrolyte separated from the anode gas-liquid separator are mixed and then distributed to the cathode and anode of the electrolysis system, respectively. In this scenario, the anode gas product and/or cathode gas product may dissolve in the electrolyte of the respective electrode. After the cathode electrolyte is mixed with the anode electrolyte, a certain amount of the anode gas product may dissolve in the cathode electrolyte. This portion of the anode gas product may then circulate with the electrolyte flow to the cathode gas-liquid separator, where it may be released along with the cathode gas product during the separation process. This could result in the cathode gas product from the cathode gas-liquid separator containing an excessive amount of the anode gas product, thereby creating a potential chemical hazard. Of course, conversely, it is also possible for a certain amount of the cathode gas product to dissolve in the anode electrolyte and flow to the anode gas-liquid separator, where it may be released along with the anode gas product during separation. This situation can be understood similarly with reference to the above description.

[0006] Therefore, there is a need for a system or method capable of reducing the content of specific gas products in the circulated electrolyte to limit the poten-

tial release of these gas products during circulation back to the electrolysis system.

Summary of the Invention

[0007] According to one aspect of the present invention, the invention relates to an electrolyte circulation system for an electrolysis system, wherein the electrolysis system is configured to electrolytically produce a desired gas. The electrolyte circulation system comprises: a primary gas-liquid separator configured to receive a mixture of the desired gas and an electrolyte to perform primary gas-liquid separation of the desired gas and the electrolyte therein; a pressure reduction device configured to be connected to the gas-liquid separator performing primary separation of the desired gas such that the electrolyte after primary gas-liquid separation flows through the pressure reduction device to reduce its pressure; a secondary gas-liquid separator configured to be connected to the pressure reduction device to receive the pressure-reduced electrolyte and perform secondary gas-liquid separation thereon to further separate the desired gas; a pressurization device configured to be connected to the secondary gas-liquid separator to pressurize the electrolyte after secondary gas-liquid separation; and a mixing supply device configured to receive and mix the pressurized electrolyte and another electrolyte from another electrode and supply the mixed electrolyte back to the electrolysis system.

[0008] According to another aspect of the present invention, the invention relates to an electrolyte circulation system for an electrolysis system, comprising: a first primary gas-liquid separator configured to receive a first gas-liquid mixture from a cathode to perform primary gas-liquid separation of a first gas and a first electrolyte therein; a second primary gas-liquid separator configured to receive a second gas-liquid mixture from an anode to perform primary gas-liquid separation of a second gas and a second electrolyte therein; a pressure reduction device configured to be connected to at least one of the first primary gas-liquid separator and/or the second primary gas-liquid separator such that the first electrolyte and/or the second electrolyte after primary gas-liquid separation flows through the corresponding pressure reduction device to reduce its pressure; a secondary gas-liquid separator configured to be connected to the pressure reduction device to receive the pressure-reduced first electrolyte and/or second electrolyte and perform secondary gas-liquid separation thereon to further separate the corresponding first gas or second gas dissolved in the first electrolyte and/or the second electrolyte; a pressurization device configured to be connected to the secondary gas-liquid separator to pressurize the first electrolyte and/or the second electrolyte after secondary gas-liquid separation; and a mixing supply device configured to receive and mix the processed first electrolyte and second

electrolyte and supply them back to the electrolysis system.

[0009] According to yet another aspect of the present invention, the invention relates to an electrolysis system, comprising: an electrolysis cell configured to electrolyze an electrolyte supplied thereto to generate a first gas at a cathode and a second gas at an anode; an electrolyte circulation system configured as the electrolyte circulation system according to any of the preceding aspects; a solution replenishment source configured to supply an electrolyte solution to the electrolysis cell to replenish electrochemical consumption; and a power supply configured to supply power to the electrolysis cell.

[0010] According to yet another aspect of the present invention, the invention relates to a control method for an electrolyte circulation system of an electrolysis system, the method comprising:

performing primary gas-liquid separation on a first gas-liquid mixture from a cathode via a first primary gas-liquid separator to obtain a first gas and a first electrolyte;

performing primary gas-liquid separation on a second gas-liquid mixture from an anode via a second primary gas-liquid separator to obtain a second gas and a second electrolyte;

reducing pressure of the first electrolyte and/or the second electrolyte after primary gas-liquid separation via a corresponding pressure reduction device; performing secondary gas-liquid separation on the pressure-reduced first electrolyte and/or second electrolyte via a corresponding secondary gas-liquid separator to further separate the corresponding first gas or second gas dissolved in the first electrolyte and/or the second electrolyte;

pressurizing the first electrolyte and/or the second electrolyte after secondary gas-liquid separation via a corresponding pressurization device; and receiving and mixing the processed first electrolyte and second electrolyte and supplying them back to the electrolysis system.

[0011] According to yet another aspect of the present invention, the invention relates to a storage medium configured to store computer-executable instructions that, when executed, implement the control method as described above.

[0012] With the present application, it ensures, on one hand, a relatively low content of the desired gas in the electrolyte after secondary gas-liquid separation to enhance separation effectiveness, thereby reducing the release amount of this dissolved desired gas during the circulation of the electrolyte at the opposite electrode.

Brief Description of the Drawings

[0013]

FIG. 1 shows a schematic diagram of an overall schematic view of an electrolysis system including an electrolyte circulation system according to the present application, wherein only one branch of the two branches in the electrolyte circulation system is provided with a secondary gas-liquid separation section; and

FIG. 2 shows an overall flowchart of a control method for an electrolysis system according to the present application.

Detailed Description of the Embodiments

[0014] The details shown herein are by way of example only, for illustrative discussion of the disclosed embodiments, and for providing a description that is readily understood in terms of principles and concepts. In this regard, no attempt is made to show structural details more elaborately, except as necessary for a fundamental understanding, and the description in conjunction with the drawings makes it clear to those skilled in the art how the disclosed electrolyte circulation system and the corresponding electrolysis system are embodied in practice.

[0015] FIG. 1 shows a schematic diagram of an overall schematic view of an electrolysis system 10 including an electrolyte circulation system 102 according to the present application. Therefore, the electrolyte circulation system 102 according to the present application and its corresponding configuration will be described in detail with reference to FIG. 1. It should be noted that in the embodiment of FIG. 1 of the present application, various components are not drawn to scale but are only schematically described to indicate the positions and relative relationships of the corresponding components. In the embodiment of FIG. 1, arrows indicate the flow direction of fluids such as liquids, gas-liquid mixtures, etc., present therein.

[0016] As shown in FIG. 1, the electrolysis system 10 generally includes: An electrolysis generation component 104, such as an electrolysis cell, configured to electrolyze an electrolyte supplied thereto to generate a desired product. In the embodiment of the present application, the desired product includes at least one gas. Optionally, in the embodiment of the present application, a first gas G1 and a second gas G2 are generated at the cathode 1040 and the anode 1042, respectively. Optionally, the first gas G1 is hydrogen and the second gas G2 is oxygen. In this case, the electrolyte is selected as an aqueous solution containing a selected electrolyte to enable electrolytic preparation of hydrogen and oxygen. It should be understood that the selected electrolyte is chosen from those that do not interfere with the preferential electrolysis of water.

[0017] In the electrolysis system 10, the general configuration of the electrolysis generation component 104, such as an electrolysis cell, is well-known to those skilled in the art and will not be elaborated upon further here. Regarding the type of electrolysis cell or electrolysis generation component, no limitation is imposed here, and it should be understood to encompass any suitable form foreseeable or employed in the art.

[0018] In the electrolysis system 10, as the electrolysis process proceeds, the desired product in gaseous form, entraining electrolyte mist, is discharged together from the electrolysis generation component 104, such as the electrolysis cell. Subsequently, the gas is separated from the electrolyte using a gas-liquid separator well-known to those skilled in the art. At this point, the electrolyte mist is converted into a liquid state, for example, via heat exchange, while the desired product in gaseous form is directed to a collection system for collection. It should be understood that before or after collecting the desired product in gaseous form via the gas-liquid separator, a gas scrubbing device may also be included. The function and configuration of such a gas scrubbing device are also well-known to those skilled in the art and will not be elaborated upon further here.

[0019] To achieve effective utilization of the electrolyte, the electrolyte, which reverts to a liquid state after gas-liquid separation treatment, is typically optionally recycled. Optionally, the respective electrolytes discharged from the cathode and anode are subjected to treatment such as gas-liquid separation, then appropriately mixed (to, for example, balance acidity/alkalinity, etc.) and supplied back to the electrolysis cell or electrolysis generation component 104 for reuse.

[0020] Alternatively, the respective electrolyte discharged from one of the cathode or anode is subjected to treatment such as gas-liquid separation and then directly supplied back to the electrolysis cell or electrolysis generation component 104 for reuse. This configuration for recycling the electrolyte discharged from the cathode or anode is also referred to as the electrolyte circulation system 102.

[0021] However, as mentioned earlier, in the prior art, the electrolyte separated by a single gas-liquid separator is directly mixed with the electrolyte discharged from the other electrode and recycled, or recycled directly back to the electrolysis generation component 104 or electrolysis cell without mixing. Since the desired product in gaseous form is under pressure in the gas-liquid separator (typically significantly greater than atmospheric pressure), a portion of it inevitably dissolves in the electrolyte that has reverted to a liquid state. In the case where this electrolyte to be recycled is directly circulated back to the electrolysis generation component 104 without mixing, the dissolved desired product may affect the efficiency of electrolysis at that electrode. Furthermore, especially when the electrolyte is mixed as described above and then recycled back to the electrolysis generation component 104 or electroly-

sis cell, since it is mixed beforehand with the recycled electrolyte from the other electrode (e.g., for neutralizing acidity/alkalinity, etc.), this dissolved gas ultimately becomes distributed and dispersed in the respective electrolytes used for both the anode and cathode. This cross-electrode distribution or dispersion of the gas, at a minimum, may affect the efficiency in the other electrode within the electrolysis generation component 104 or electrolysis cell, which is opposite to the electrode generating the desired product. More seriously, for an electrolysis system 10 where the respective products from both the cathode and anode include corresponding desired products in gaseous form, this mixing leads to the eventual mixing of the gases from both electrodes. On one hand, this mixing affects the purity of the gases. On the other hand, since the two gases generated by electrolysis are usually relatively chemically active, repeated mixing with the electrolyte can cause the two gases to reach a dangerous proportion threshold at a certain electrode or location (e.g., the gas-liquid separator of a certain electrode), creating a risk. Here, electrolytic preparation of hydrogen and oxygen will be used as an example to describe this particularly dangerous situation, but it should be understood that this description is exemplary and not limiting. Such a dangerous situation may occur in electrolysis systems 10 for other desired products and is not limited here.

[0022] In conventional electrolysis systems for producing hydrogen and oxygen through electrolysis, the hydrogen generated at the cathode 1040 is separated from the first electrolyte via a first primary gas-liquid separator (e.g., connected to the cathode outlet of the electrolysis component), allowing most of the hydrogen to be separated. Similarly, the oxygen generated at the cathode 1042 is separated from the second electrolyte via a second primary gas-liquid separator (e.g., connected to the anode outlet of the electrolysis component), allowing most of the oxygen to be separated. Subsequently, the first electrolyte and the second electrolyte are mixed and supplied back to the electrolysis cell or the electrolysis component. It should be noted that additional water or electrolyte may be supplemented to one or both of the first and second electrolytes before or after mixing, which is not limited herein. During mixing, the hydrogen dissolved in the first electrolyte and the oxygen dissolved in the second electrolyte are also mixed accordingly and supplied to the anode of the electrolysis component 104. This mixed hydrogen further circulates to the second primary gas-liquid separator with the electrolysis process, leading to a certain degree of hydrogen accumulation in the second primary gas-liquid separator. As the electrolyte circulation continues, this hydrogen accumulation may reach a threshold proportion where hydrogen and oxygen react violently, posing risks such as explosions. This significantly increases the risk of hazards, especially in large-scale electrolysis systems. In the prior art, methods such as periodically purging residual gases from

the second primary gas-liquid separator or completely replacing the electrolyte are used to avoid the aforementioned hazards. However, the replacement frequency may be relatively high, leading to significantly increased costs.

[0023] In this context, the present application proposes an electrolyte circulation system 102 as shown in the embodiment of FIG. 1 of this application to reduce the aforementioned risks, thereby potentially lowering maintenance frequency and saving costs.

[0024] As shown in FIG. 1, the electrolysis system 10 is configured to produce a desired gas at least one of the cathode 1040 and the anode 1042. In this case, the electrolyte circulation system 102 for the electrolysis system 10 may include: A primary gas-liquid separator 1020-1, configured to receive a mixture of the desired gas and the entrained electrolyte, particularly in an aerosol state, and perform primary gas-liquid separation of the desired gas and the electrolyte in the mixture. As mentioned earlier, the construction and principles of the primary gas-liquid separator 1020-1 are well-known to those skilled in the art and will not be described in detail here.

[0025] The electrolyte circulation system 102 further includes a pressure reduction device 1022, configured to be connected to the gas-liquid separator 1020 that performs primary gas-liquid separation of the desired gas, such that the electrolyte after primary gas-liquid separation flows through the pressure reduction device 1022 to reduce its pressure. It should be understood that the electrolyte is restored to a liquid state after passing through the primary gas-liquid separator 1020-1, which is well-known to those skilled in the art. At this point, due to the accumulation of the desired gas in the gas-liquid separator (typically a sealed container), the primary gas-liquid separator 1020-1 maintains a certain gas pressure level, and thus the resulting liquid electrolyte maintains a corresponding liquid pressure level. That is, the gas pressure level in the primary gas-liquid separator 1020-1 caused by the desired gas is typically relatively high, resulting in a relatively high liquid pressure of the resulting liquid electrolyte. In this case, the dissolution amount of the desired gas in the liquid electrolyte is also relatively high (e.g., compared to atmospheric pressure or other lower pressure conditions). Therefore, a pressure reduction device is provided to reduce the pressure of the electrolyte, thereby further reducing the dissolution amount of the desired gas in the electrolyte.

[0026] The electrolyte circulation system 102 further includes a secondary gas-liquid separator 1024, configured to be connected to the aforementioned pressure reduction device 1022 to receive the pressure-reduced electrolyte and perform secondary gas-liquid separation to further separate the desired gas. In other words, in the secondary gas-liquid separator 1024, due to the reduced liquid pressure, the desired gas is further released from the electrolyte, for example, by forming

bubbles. At this point, the secondary gas-liquid separator 1024 can guide the released desired gas for collection and further separate the desired gas from the electrolyte. Optionally, the desired gas pressure level in the secondary gas-liquid separator 1024 is maintained significantly lower than that in the primary gas-liquid separator 1020-2 before the pressure reduction device 1022, to ensure that the dissolution level of the desired gas in the electrolyte is reduced to the desired extent. Additionally, the secondary gas-liquid separator 1024 may be equipped with devices such as a stirring mechanism to promote the thorough release of bubbles formed due to pressure reduction.

[0027] The electrolyte circulation system 102 further includes a pressurization device 1026, configured to be connected to the secondary gas-liquid separator 1024 to pressurize the electrolyte after secondary gas-liquid separation. As those skilled in the art will understand, due to the aforementioned pressure reduction device 1022, the liquid pressure of the electrolyte at this point has been reduced. On one hand, this liquid pressure is lower than the electrolyte pressure in the electrolysis cell or electrolysis component. On the other hand, the liquid pressure of this electrolyte may also be lower than that of the electrolyte from the other electrode of the electrolysis system (if present). At this point, since it needs to be mixed with the electrolyte from the other electrode of the electrolysis system, it is necessary to ensure that the liquid pressures of the two electrolytes are substantially equal, preferably equal, to allow thorough and easy mixing of the two electrolytes. Furthermore, before being supplied back to the electrolysis cell or electrolysis component 104, it may also be necessary to ensure that the liquid pressure of the mixed electrolyte obtained from the two electrolytes is substantially equal to or equal to the electrolyte pressure in the electrolysis cell or electrolysis component 104, to facilitate the supply of the mixed electrolyte back to the electrolysis cell or electrolysis component 104. It can be envisioned that since the electrolyte from the other electrode may not undergo secondary gas-liquid separation treatment, the electrolyte from the other electrode may have a higher pressure, requiring a pressurization operation on the electrolyte that has undergone secondary gas-liquid separation before mixing.

[0028] The electrolyte circulation system 102 further includes a mixing supply device 1028, such as a pump, configured to receive and mix the pressurized electrolyte and another electrolyte from the other electrode, and supply the mixed electrolyte back to the electrolysis cell or electrolysis component 104. The construction of this mixing supply device is well-known to those skilled in the art and will not be described in detail here.

[0029] Optionally, the electrolysis system produces gas products at both the cathode and anode. In this case, the aforementioned electrolyte circulation system 102 can be applied as the electrolyte circulation system for each electrode of the electrolysis system. This is

particularly the case in electrolysis for producing hydrogen and oxygen.

[0030] For an electrolysis system 10 that produces gas products at both the cathode and anode, its electrolyte circulation system 102 can be described as including a first primary gas-liquid separator 1020-1, which is configured to receive a first gas-liquid mixture from the cathode to perform primary gas-liquid separation of the first gas and the first electrolyte therein. Furthermore, the electrolyte circulation system includes a second primary gas-liquid separator 1020-2, which is configured to receive a second gas-liquid mixture from the anode to perform primary gas-liquid separation of the second gas and the second electrolyte therein.

[0031] Similarly, the electrolyte circulation system 102 includes a pressure reduction device 1022, which is configured to be connected to at least one of the first primary gas-liquid separator 1020-1 and/or the second primary gas-liquid separator 1020-2, such that the first electrolyte and/or the second electrolyte after primary gas-liquid separation flows through the corresponding pressure reduction device 1022 to reduce its pressure. Similarly, the electrolyte circulation system 102 also includes a secondary gas-liquid separator 1024, which is configured to be connected to the pressure reduction device 1022 to receive the pressure-reduced corresponding first electrolyte and/or the second electrolyte and perform secondary gas-liquid separation thereon to further separate the first electrolyte and/or the second electrolyte and the corresponding first gas or second gas dissolved therein. Similarly, the electrolyte circulation system 102 further includes a pressurization device 1026, which is configured to be connected to the secondary gas-liquid separator 1024 to pressurize the first electrolyte and/or the second electrolyte after secondary gas-liquid separation. Similarly, the electrolyte circulation system 102 further includes a mixing supply device 1028, which is configured to receive and mix the processed first electrolyte and second electrolyte and supply them back to the electrolysis system. It should be understood that in the above case of the electrolysis system 10 producing gas products at both the cathode and anode, the meaning of "processed" should be understood to include the following two situations: Both the first and second electrolytes undergo secondary gas-liquid separation; and only one of the first and second electrolytes undergoes secondary gas-liquid separation while the other only undergoes primary gas-liquid separation.

[0032] In the case where both the first and second electrolytes undergo secondary gas-liquid separation, the mixing supply device 1028 optionally integrates the pressurization device 1026 or is placed before the pressurization device and directly connects the two secondary gas-liquid separators 1024; in this optional case, that is, the first and second electrolytes can be mixed first and then pressurized, or mixing, pressurization, and pumping can be performed substantially simulta-

neously.

[0033] In the case of an electrolysis system 10 for hydrogen and oxygen production via electrolysis, the above-mentioned primary gas-liquid separator, pressure reduction device, secondary gas-liquid separation device, and pressurization pump may be provided only in the electrolyte circulation branch on the cathode side (hydrogen generation side), while only a primary gas-liquid separator is provided in the electrolyte circulation branch on the anode side, which then directly circulates to the mixing supply device 1028. In this case, the hydrogen content in the mixed electrolyte is significantly lower than the oxygen content, causing the amount of hydrogen precipitated in the second primary gas-liquid separator 1020-2 on the electrode side where oxygen is generated to be significantly reduced or even completely suppressed (due to the gas pressure in the primary gas-liquid separator (and thus the corresponding liquid pressure of the electrolyte therein) remaining at a considerable level), thereby avoiding the probability of danger that may occur in the second primary gas-liquid separator 1020-2.

[0034] Furthermore, as those skilled in the art will understand, the electrolysis system 10 additionally includes a solution replenishment source 106, which is configured to supply an electrolyte solution to the electrolysis cell to replenish electrochemical consumption. It should be understood that in the embodiments of the present application, "electrolyte solution" refers to the original electrolyte used for electrolysis that has not undergone electrolyte circulation; of course, this electrolyte solution can be supplied in various ways without departing from the scope of the present application. For example, the solution replenishment source 106 includes a solvent source and a solute source to supply solvent and solute respectively, whether the solvent and solute are mixed before supply or supplied separately for real-time mixing, both are included within the scope of the present application. It is also conceivable that, for example, in the case of hydrogen and oxygen production via electrolysis, the solution replenishment source 106 optionally includes a water solvent source to supply to the electrolysis cell or the electrolysis component 104. For example, when the solution replenishment source 106 includes a water solvent source, the water solvent source can be connected to the side not subjected to secondary gas-liquid separation treatment, for example, in the case of electrolytic production of first and second gases, directly connected to the corresponding primary gas-liquid separator on that side to directly supplement the water solvent into the corresponding electrolyte after primary gas-liquid separation on that side, and then supplement it to the electrolysis system via the circulation system. In particular, the water solvent can be selected as a low-pressure water solvent to reduce the liquid pressure of the electrolyte in the primary gas-liquid separator on that side. Of course, for example, in the case of hydrogen and oxy-

gen production via electrolysis, the solution replenishment source 106 may also include a high-concentration solute solution, which is connected to any possible location to supplement possible electrolyte consumption losses in the electrolysis system. In other words, in the embodiments of the present application, when secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, on the side of the electrolyte not subjected to secondary gas-liquid separation, a low-pressure solvent or low-pressure electrolyte is supplemented in the corresponding primary gas-liquid separator.

[0035] Of course, the electrolysis system also includes a power supply 108, which is configured to supply power to the electrolysis cell or the electrolysis component, especially direct current.

[0036] In the context of the electrolysis cell, the electrolysis cell includes a chamber comprising an anode electrolyte chamber and a cathode electrolyte chamber separated by a separator (such as an ion exchange membrane or various other possible forms), and the electrolyte is supplied to the anode electrolyte chamber and the cathode electrolyte chamber respectively.

[0037] As mentioned earlier, it is conceivable that to ensure easy mixing of the first and second electrolytes, the pressurization device 1026 is particularly configured to pressurize the electrolyte (first or second electrolyte) after secondary gas-liquid separation such that the liquid pressures of the first electrolyte and the second electrolyte are equal. Of course, for the case where both the first and second electrolytes undergo secondary gas-liquid separation, this situation can be expressed as performing the same degree of pressure reduction and pressurization operations on the first and second electrolytes. Additionally, optionally, for the case where both the first and second electrolytes undergo secondary gas-liquid separation, the first and second electrolytes are pressurized to the same degree such that the liquid pressure of the mixed first and second electrolytes is comparable or equal to the liquid pressure of the electrolyte in the electrolysis cell or the electrolysis component.

[0038] Additionally, as described throughout this document, the first gas is selected as hydrogen and the second gas is selected as oxygen. In this case, optionally, only the electrolyte circulation branch on the hydrogen side is equipped with relevant devices for secondary gas-liquid separation treatment, while the electrolyte circulation branch on the oxygen side is only subjected to primary gas-liquid separation treatment before being circulated back to the electrolysis cell or the electrolysis generation component 104.

[0039] It is conceivable or optional that, in the case of electrolytic preparation of hydrogen and oxygen, both the first electrolyte and the second electrolyte are aqueous electrolyte solutions, wherein the electrolyte is selected from strong oxyacids, strong bases, or related salts. As an example, the strong oxyacid may be se-

lected as hypochlorous acid, the strong base may be selected as sodium hydroxide or potassium hydroxide (wherein the metal activity of the metal corresponding to the metal cation is higher than that of hydrogen), and the salt may be selected as sulfate (wherein the metal activity of the metal corresponding to the metal cation is higher than that of hydrogen).

[0040] As an example and non-limiting, the pressure reduction device 1022 is configured as a throttle valve. According to Bernoulli's principle, one method to reduce liquid pressure is to increase the flow velocity of the electrolyte. Therefore, the throttle valve is configured such that the liquid flow velocity on the side connected to the primary gas-liquid separator 1020 is lower than that on the side connected to the secondary gas-liquid separator 1024. In this case, the liquid pressure of the electrolyte flowing through the throttle valve is significantly reduced. Of course, other devices for reducing liquid pressure, such as pressure relief valves, may be considered without departing from the scope of this application.

[0041] As an example and non-limiting, the first primary gas-liquid separator 1020-1 and the second primary gas-liquid separator 1020-2 are respectively connected to corresponding first gas collection device 1050 and second gas collection device 1052. In the case of hydrogen and oxygen, the first gas collection device 1050 is a hydrogen gas collection device, and the second gas collection device 1052 is an oxygen gas collection device. As for the gas treatment and enrichment processes of the relevant first and second gases from the first and second primary gas-liquid separators to the first and second gas collection devices, these are well-known to those skilled in the art and will not be elaborated further here.

[0042] As an example and non-limiting, the secondary gas-liquid separator 1024 according to an embodiment of this application is configured to be connected to the corresponding gas collection device in accordance with the electrolyte undergoing gas-liquid separation to achieve secondary gas collection. In other words, if secondary gas-liquid separation is performed on the first gas, the relevant secondary gas-liquid separator 1024 is also connected to the first gas collection device 1050, and similarly for the second gas. As for the gas treatment and enrichment processes of the relevant first and/or second gases from the corresponding secondary gas-liquid separator 1024 to the corresponding first and/or second gas collection devices, these are well-known to those skilled in the art and will not be elaborated further here.

[0043] As an example and non-limiting, the pressurization device 1026 is configured as a pressurization pump or compression pump, enabling the electrolyte after secondary gas-liquid separation to be pressurized to a desired pressure level.

[0044] As an example and non-limiting, the mixed first electrolyte and second electrolyte are configured

to be supplied to the cathode electrolysis zone and anode electrolysis zone of the electrolysis system according to a set distribution for reuse in electrolysis. It should be understood that this "set distribution" is configured based on the consumption levels of the electrolyte at the cathode and anode (electrolytic consumption or consumption due to gas flow). Clearly, the electrode with faster electrolyte consumption is allocated more circulating electrolyte. This is merely exemplary and non-limiting. For some electrolysis systems, the circulating electrolyte may be supplied to a common area, in which case no such distribution needs to be considered.

[0045] As an example and non-limiting, the first primary gas-liquid separator 1020-1 and the second primary gas-liquid separator 1020-2 are respectively connected to the corresponding first gas collection device 1050 and second gas collection device 1052 via a first shut-off valve 1030 and a second shut-off valve 1032 to prevent gas collected in the gas collection devices from flowing back into the corresponding primary gas-liquid separators, especially when the gas pressure in the gas collection devices is greater than that in the corresponding primary gas-liquid separators.

[0046] It is emphasized here that although FIG. 1 shows that the secondary gas-liquid separation treatment is only provided in the cathode electrolyte circulation branch, those skilled in the art can envision that this secondary gas-liquid separation treatment may alternatively be provided only in the anode electrolyte circulation branch or simultaneously in both the anode and cathode electrolyte circulation branches.

[0047] FIG. 2 shows an overall flowchart of a control method for an electrolyte circulation system of an electrolysis system according to the present application. As shown in FIG. 2 and in conjunction with the structure of the relevant electrolyte circulation system in Figure 1, the relevant control method will be described in detail as follows.

[0048] At step 200, primary gas-liquid separation is performed on a first gas-liquid mixture from the cathode via a first primary gas-liquid separator to obtain a first gas and a first electrolyte.

[0049] At step 202, primary gas-liquid separation is performed on a second gas-liquid mixture from the anode via a second primary gas-liquid separator to obtain a second gas and a second electrolyte.

[0050] At step 204, pressure reduction is performed on the first electrolyte and/or the second electrolyte after primary gas-liquid separation via a corresponding pressure reduction device. For example, pressure reduction is performed on only one of the first electrolyte and the second electrolyte or on both.

[0051] At step 206, secondary gas-liquid separation is performed on the pressure-reduced first electrolyte and/or second electrolyte via a corresponding secondary gas-liquid separator to further separate the first electrolyte and/or the second electrolyte from the corre-

sponding first gas or second gas dissolved therein. For example, only one of the first and second electrolytes is further separated from the corresponding one of the first and second gases dissolved therein. Or, for example, the first and second electrolytes are further separated from the corresponding first and second gases dissolved therein, respectively, such that both the first and second electrolytes undergo secondary gas-liquid separation.

[0052] At step 208, pressurization is performed on the first electrolyte and/or the second electrolyte after secondary gas-liquid separation via a corresponding pressurization device. For example, pressurization is performed only on the electrolyte among the first and second electrolytes that has undergone secondary gas-liquid separation, or pressurization is performed on both the first and second electrolytes that have undergone secondary gas-liquid separation separately.

[0053] At step 210, the processed first electrolyte and second electrolyte are received, mixed, and supplied back to the electrolysis system. Here, the processed first and second electrolytes refer to: the first electrolyte after secondary gas-liquid separation and the second electrolyte after primary gas-liquid separation; or the first electrolyte after primary gas-liquid separation and the second electrolyte after secondary gas-liquid separation; or both the first electrolyte and the second electrolyte after secondary gas-liquid separation.

[0054] By way of example and not limitation, the control method according to an embodiment of the present application further comprises monitoring the liquid pressure of the corresponding electrolyte to undergo secondary gas-liquid separation or the gas pressure of its corresponding primary gas-liquid separator, so as to ensure that a desired pressure reduction is achieved when the electrolyte flows through the pressure reduction device, for example, by measuring the relevant liquid pressure or gas pressure via corresponding sensing elements. Through such monitoring, relevant parameters of the pressure reduction device can be adjusted to achieve a stable desired pressure reduction, for example, ensuring that the electrolyte flowing through the pressure reduction device is reduced to a predetermined liquid pressure.

[0055] By way of example and not limitation, the control method according to an embodiment of the present application further comprises, in the case where secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, monitoring the liquid pressure of the other of the first electrolyte and the second electrolyte after primary gas-liquid separation to correspondingly adjust the pressurization device, so as to ensure pressure balance, or even equality or equivalence, between the pressurized electrolyte that has undergone secondary gas-liquid separation and the other electrolyte. This facilitates the mixing of the two electrolytes.

[0056] By way of example and not limitation, the con-

trol method according to an embodiment of the present application further comprises, in the case where secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, supplementing a low-pressure electrolyte solution or electrolyte solvent via the primary gas-liquid separator on the side not subjected to secondary gas-liquid separation. In this way, the electrolytic loss of the electrolyte can be replenished, and the liquid pressure in the primary gas-liquid separator on that side can be reduced, which aids in gas evolution.

[0057] Of course, it is also possible to consider monitoring at least one of the flow rates of the first gas-liquid mixture and the second gas-liquid mixture, the collection amounts of the first gas and the second gas, and the total flow rate of the electrolyte circulated back to the electrolysis system, and based on the detection results, supplementing a low-pressure electrolyte solution or electrolyte solvent via the primary gas-liquid separator on the side not subjected to secondary gas-liquid separation. Through this, the electrolytic loss of the electrolyte can be replenished at a desired flow rate without causing excess and while also reducing temperature and other effects.

[0058] Of course, the present invention also relates to a storage medium configured to store computer-executable instructions such that, when the instructions are executed, the control method for the electrolyte circulation system as described above can be implemented. This storage medium may be integrated into the overall control system of the electrolysis system without departing from the scope of the present application.

[0059] It should be understood that although the control method for the electrolyte circulation system of the electrolysis system according to the embodiments of the present application has been described above in a certain order, the sequence of these steps is not limiting but exemplary. Some of these steps may be performed in reverse order, concurrently, or integrated into other steps; or one of these steps may be divided into multiple steps to perform, or some of these steps may be performed in a single step without departing from the scope of the present application.

[0060] Although the present application has been described with reference to the drawings and embodiments of the present application, those skilled in the art can conceive of various modifications based on the teachings of the present application without departing from the scope of the present application.

Claims

1. An electrolyte circulation system for an electrolysis system, wherein the electrolysis system is configured to electrolytically produce a desired gas, and the electrolyte circulation system comprises:

a primary gas-liquid separator configured to receive a mixture of the desired gas and an electrolyte to perform primary gas-liquid separation of the desired gas and the electrolyte therein;

a pressure reduction device configured to be connected to the primary gas-liquid separator such that the electrolyte after primary gas-liquid separation flows through the pressure reduction device to reduce its pressure;

a secondary gas-liquid separator configured to be connected to the pressure reduction device to receive the pressure-reduced electrolyte and perform secondary gas-liquid separation thereon;

a pressurization device configured to be connected to the secondary gas-liquid separator to pressurize the electrolyte after secondary gas-liquid separation; and

a mixing supply device configured to receive and mix the pressurized electrolyte and another electrolyte from another electrode and supply the mixed electrolyte back to the electrolysis system.

2. An electrolyte circulation system for an electrolysis system, wherein the electrolyte circulation system comprises:

a first primary gas-liquid separator configured to receive a first gas-liquid mixture from a cathode to perform primary gas-liquid separation of a first gas and a first electrolyte therein;

a second primary gas-liquid separator configured to receive a second gas-liquid mixture from an anode to perform primary gas-liquid separation of a second gas and a second electrolyte therein;

a pressure reduction device configured to be connected to at least one of the first primary gas-liquid separator and/or the second primary gas-liquid separator such that the first electrolyte and/or the second electrolyte after primary gas-liquid separation flows through the corresponding pressure reduction device to reduce its pressure;

a secondary gas-liquid separator configured to be connected to the pressure reduction device to receive the pressure-reduced first electrolyte and/or second electrolyte and perform secondary gas-liquid separation thereon;

a pressurization device configured to be connected to the secondary gas-liquid separator to pressurize the first electrolyte and/or the second electrolyte after secondary gas-liquid separation; and

a mixing supply device configured to receive and mix the processed first electrolyte and

- second electrolyte and supply them back to the electrolysis system.
3. The electrolyte circulation system according to Claim 2, wherein the pressurization device is configured to pressurize the first electrolyte and/or the second electrolyte after secondary gas-liquid separation such that the liquid pressures of the first electrolyte and the second electrolyte are equal.
 4. The electrolyte circulation system according to Claim 2, wherein the first gas is selected as hydrogen and the second gas is selected as oxygen.
 5. The electrolyte circulation system according to Claim 2, wherein the pressure reduction device is configured as a throttle valve.
 6. The electrolyte circulation system according to Claim 2, wherein the first primary gas-liquid separator and the second primary gas-liquid separator are respectively connected to corresponding first gas collection device and second gas collection device.
 7. The electrolyte circulation system according to Claim 6, wherein the first primary gas-liquid separator and the second primary gas-liquid separator are respectively connected to the corresponding first gas collection device and second gas collection device via a first shut-off valve and a second shut-off valve.
 8. The electrolyte circulation system according to Claim 2, wherein, when secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, on the side of the electrolyte not subjected to secondary gas-liquid separation, a low-pressure solvent or low-pressure supplementary electrolyte is added in the corresponding primary gas-liquid separator.
 9. An electrolysis system, comprising:
 - an electrolysis cell configured to electrolyze an electrolyte supplied thereto to generate a first gas at a cathode and a second gas at an anode;
 - an electrolyte circulation system configured as the electrolyte circulation system according to any one of Claims 2-8;
 - a solution replenishment source configured to supply at least one of an electrolyte solution and an electrolyte solvent to the electrolysis cell to replenish electrochemical consumption;
 - and
 - a power supply configured to supply power to the electrolysis cell.
 10. A control method for an electrolyte circulation system of an electrolysis system, wherein the control method comprises:
 - performing primary gas-liquid separation on a first gas-liquid mixture from a cathode via a first primary gas-liquid separator to obtain a first gas and a first electrolyte;
 - performing primary gas-liquid separation on a second gas-liquid mixture from an anode via a second primary gas-liquid separator to obtain a second gas and a second electrolyte;
 - reducing pressure of the first electrolyte and/or the second electrolyte after primary gas-liquid separation via a corresponding pressure reduction device;
 - performing secondary gas-liquid separation on the pressure-reduced first electrolyte and/or second electrolyte via a corresponding secondary gas-liquid separator;
 - pressurizing the first electrolyte and/or the second electrolyte after secondary gas-liquid separation via a corresponding pressurization device; and
 - receiving and mixing the processed first electrolyte and second electrolyte via a mixing supply device and supplying them back to the electrolysis system.
 11. The control method according to Claim 10, further comprising monitoring the liquid pressure of the corresponding electrolyte to undergo secondary gas-liquid separation or the gas pressure of its corresponding first or second primary separator to adjust the pressure reduction device accordingly, ensuring that the corresponding electrolyte achieves a desired pressure reduction when flowing through the pressure reduction device.
 12. The control method according to Claim 10, wherein, when secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, the control method further comprises monitoring the liquid pressure of the other of the first electrolyte and the second electrolyte after primary gas-liquid separation to adjust the pressurization device accordingly, ensuring pressure balance between the one subjected to secondary gas-liquid separation and the other.
 13. The control method according to Claim 10, wherein, when secondary gas-liquid separation is performed on only one of the first electrolyte and the second electrolyte, the control method further comprises monitoring at least one of the flow rates of the first gas-liquid mixture and the second gas-liquid mixture, the collection amounts of the first gas and the second gas, and the total flow rate of

the electrolyte circulated back to the electrolysis system, and based on the monitoring results, supplementing low-pressure electrolyte solution or electrolyte solvent via the primary gas-liquid separator on the side not subjected to secondary gas-liquid separation. 5

14. A storage medium configured to store computer-executable instructions that, when executed, implement the control method as described above. 10

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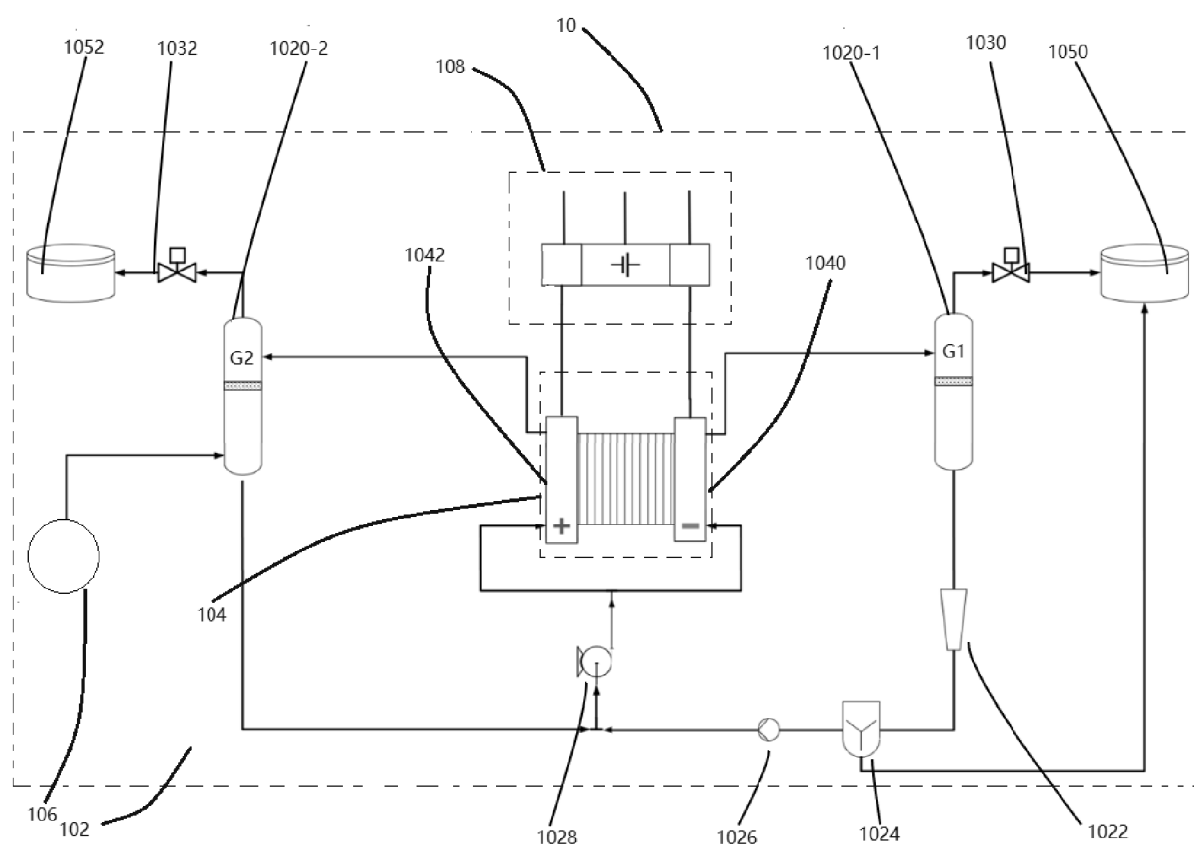


FIG. 1

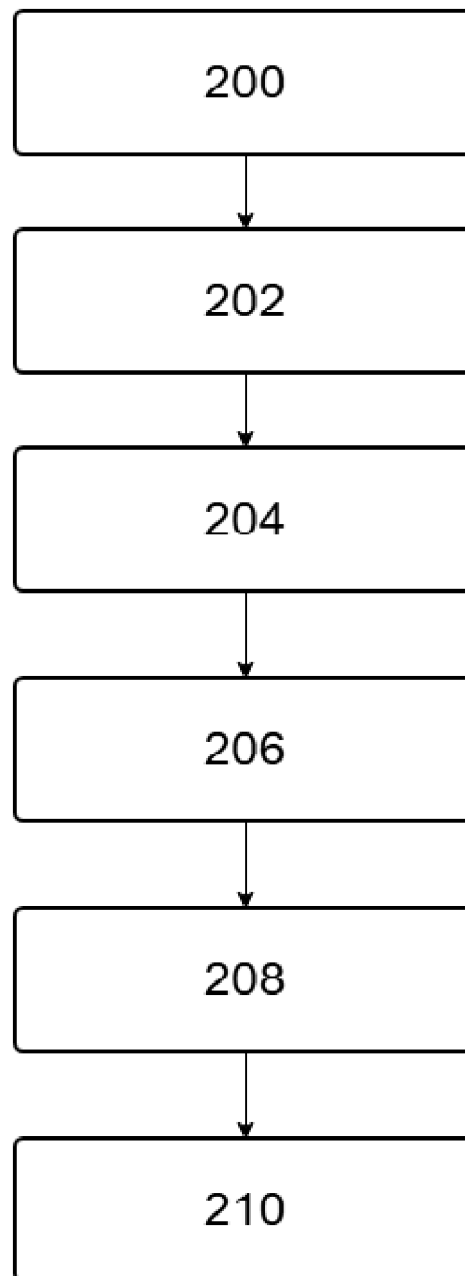


FIG. 2



EUROPEAN SEARCH REPORT

Application Number

EP 26 17 1393

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			TECHNICAL FIELDS SEARCHED (IPC)
			C25B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		26 August 2026	Teppo, Kirsi-Marja
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