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(54) **PROCESS FOR PREPARING A BUFFER SOLUTION IN A PAPERMAKING PROCESS**

VERFAHREN ZUR HERSTELLUNG EINER PUFFERLÖSUNG IN EINEM
PAPIERHERSTELLUNGSVERFAHREN

PROCÉDÉ DE PRÉPARATION D UNE SOLUTION TAMPON DANS UN PROCESSUS DE
FABRICATION DU PAPIER

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EP 2 329 078 B1

Description

[0001] The invention describes a process for preparing a buffer solution in an industrial papermaking process, wherein the buffer solution is supplied to a main process stream, which is an aqueous pulp suspension or a water stream leading to and/or from said suspension, comprising

- a) providing a basic and an acidic substance which substances in combination are capable to forming buffering ions which influence the alkalinity of an aqueous medium,
- b) introducing individually regulated controlled feeds of said basic and said acidic substances as well as water into the reactor of an apparatus located outside the main process stream of said papermaking process,
- c) causing said basic substance and said acidic substance to react in said water to provide a predefined alkalinity and/or pH in the resulting aqueous buffer solution,
- d) supplying said aqueous buffer solution to said main process stream for controlling the alkalinity, pH and/or hardness in the said process stream.

[0002] During the last twenty years many paper makers have converted their processes from acidic to neutral pH for a number of reasons, e.g. to gain increased strength and to be able to use calcium carbonate, CaCO_3 , as a filler. The expression "neutral pH" corresponds in these processes to a pH in the short circulation of approximately 7-8.5, most preferably 7-8. This applies to paper produced from chemical, mechanical and recycled pulp, bleached or unbleached.

[0003] If the papermaking pulp is acidic when entering the stock preparation and the short circulation is run at a neutral or alkaline pH, the traditional way of raising and controlling the pH is to add sodium hydroxide, NaOH. NaOH is a very strong base, which means that only a small amount is needed for pH adjustment. Any over dosage will cause a too big pH increase, which means that it is difficult to perform the pH adjustment in a controlled way. This is due to the low inherent buffering ability of a pulp suspension. The paper maker could end up in a situation with varying pH of the entering pulp, which has negative impact on paper quality and paper machine run ability.

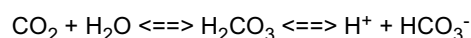
[0004] Through the stock preparation and the short circulation a number of paper chemicals and dilution waters are added, some of which are acidic and therefore decrease the pH of the pulp. The paper maker could therefore end up with a too low pH in the short circulation and would be once again forced to pH adjust using NaOH. The pH may also change at refining or in storage towers.

[0005] If the paper making pulp is alkaline instead when entering the stock preparation and if the short circulation is run at a neutral or alkaline pH, there is naturally no need to use any NaOH for pH control. The paper maker must however make sure that the pH is high enough to avoid ending up with too low pH after addition of acidic paper chemicals.

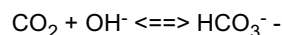
[0006] A papermaker could add dissolved sodium bicarbonate, NaHCO_3 , to the pulp to avoid ending up with too low pH values. The NaHCO_3 dissociates in the pulp suspension forming bicarbonate ions, HCO_3^- , which have a buffering effect and therefore counteract any pH decrease. NaHCO_3 is a solid powder, which is generally supplied in so called big-bags, and the paper mill needs space for handling, equipment for dissolving and tanks for storage. The NaHCO_3 is messy to work with, when in contact with moisture or water.

[0007] Thereby an alternative way to generate bicarbonate ions in the pulp suspension is used according to prior art. The bicarbonate ions were generated by the dissociation of carbon dioxide, CO_2 , in the aqueous pulp.

[0008] Carbon dioxide is a gas, which easily dissolves under alkaline conditions, e.g. in water or a pulp suspension forming carbonic acid and/or bicarbonate ions according to the reaction:



[0009] At high pH, especially greater than 10, the predominant reaction is:



[0010] Consequently, EP0991811 describes a process for stabilising the pH of a pulp suspension in the stock preparation of a paper machine by using carbon dioxide. The stabilisation is provided by increasing the buffering ability of the paper making pulp suspension by adding a combination of an alkali earth metal hydroxide feed, preferably a NaOH feed, and a carbon dioxide feed which feeds substantially counter each other's pH changing effects. The feeds are provided in an amount sufficient to achieve a significant buffering effect of said pulp suspension. The process includes adjusting the pH of the pulp suspension by addition of an excess of said hydroxide or said carbon dioxide. Thus the pH is maintained at a desired level throughout the subsequent paper making process.

[0011] The process as disclosed in EP0991811 has some difficulties especially in the addition of the sodium hydroxide and carbon dioxide. A local high pH caused by the addition of the sodium hydroxide may cause precipitation of calcium carbonate. A high pH may dissolve extractives, which may then precipitate elsewhere in the process. A high pH may

also cause yellowing of the pulp. It may also be difficult to add sufficiently carbon dioxide to the process. The addition of the basic and acidic substances is usually done separately at special dosing points. The use of basic and acidic substances often requires preprocessing, e.g. dissolving and diluting, and special equipment for that before the substances are fed into the process. Thereby it may not even be possible to feed the substances in the needed points of the process, or it may require complex equipment.

[0012] To overcome the problems according to prior art as described in EP0991811 a process and an apparatus for controlling the alkalinity, pH and/or hardness of a liquid of an industrial process is described in EP1461499.

[0013] Alkalinity is a measure of the buffering capacity of an aqueous system, i.e. the capacity to prevent pH changes. It can also be seen as a capacity to accept H^+ or OH^- ions. The buffering capacity enables the addition of acidic and basic substances to an aqueous system without significant changes in the pH. The amounts of bases and acids that can be added without affecting the pH depend on the strength and amount of the base and the acid as well as on the amount of alkalinity. Many industrial processes lack a sufficient alkalinity required for operating properly. Generally alkalinity results from the amounts of hydroxide, carbonate and bicarbonate ions in an aqueous solution according to the equation:

$$[alk] = [OH^-] + 2[CO_3^{2-}] + [HCO_3^-] - [H^+]$$

[0014] Alkalinity may also result from ammonia and the conjugate bases of phosphoric, silicic, boric and organic acids. Alkalinity is often expressed in units of mg/l of $CaCO_3$ or mmol/l of $CaCO_3$.

[0015] Alkalinity is not to be confused with pH, which is a measure of the concentration of H^+ ions ($pH = -\log[H^+]$).

[0016] The apparatus described in EP1461499 is located outside the main process stream of the papermaking process. The apparatus includes inlet means for a basic substance, an acidic substance and water, individually regulated control means for the inlet means and a reactor for reacting the basic substance, the acidic substance and the water for providing a predefined alkalinity and/or pH in the resulting aqueous buffer solution. The apparatus also includes outlet means for supplying the aqueous buffer solution to the main process stream in the papermaking process. According to the process described in EP1461499 the basic and acidic substances are capable to form buffering ions. Thereby a buffer solution is generated in the reactor and fed to the aqueous pulp suspension in the paper making process. The alkalinity, pH and/or hardness of the pulp suspension are thereby controlled by the defined alkalinity, pH and/or hardness of the buffer solution.

[0017] The process according to EP1461499 leads to some problems. As described in EP1461499 sodium hydroxide is used as basic substance and diluted in an aqueous solution, preferably water, before introducing carbon dioxide as acidic substance. The diluted NaOH solution is introduced to the reactor and then mixed with carbon dioxide to get bicarbonate as the main buffering substance in the buffer solution. NaOH is a strong base. Thereby the pH of the diluted NaOH solution is high, typically above 10 and especially above 8. When carbon dioxide is introduced at this high pH value precipitation of calcium carbonate in the reactor occurs due to calcium ions present in the water. The precipitation is a big problem in a process according to the prior art. According to prior art the problem is partly solved by the use of a chelating agent which prohibits the reaction of the calcium ion with the carbonate ion and thereby the precipitation. The chelating agents are expensive. Additionally the chelating agents are not always degenerated in the following waste water treatment equipment and could end up in the nature. Another possibility to deal with the precipitation is to use softened water from which the calcium ions have been removed. However, this is expensive and not suitable for large industrial processes. Thus, the prior art typically necessitates a periodic cleaning of the equipment with an acid. This is expensive, leads to a shutdown of the process and increases the possibility of accidents.

[0018] Therefore, it is an object of the invention to show a process for preparing a buffer solution in a papermaking process which reduces the precipitation of calcium carbonate in the reactor without using expensive chelating agents.

[0019] This object is achieved by a process of the above type, whereby the pH is kept below 7.5 during the whole process of adding the acidic substance. Keeping the pH below 7.5 during the buffer production stage is the fundamental idea of the invention.

[0020] Surprisingly no precipitation occurs at a pH below 7.5 which was shown by new experiments. Hence there is no need for expensive chelating agents and shutdowns of the process for cleaning the equipment with acid. Thereby the profitability of the process is increased.

[0021] Advantageously the said basic substance comprises an alkali metal hydroxide, an alkali metal carbonate, an alkali metal bicarbonate, an alkali metal phosphate, an alkali metal biphosphate and/or an alkali metal phosphite and/or green liquor or white liquor and the said acidic substance comprises gaseous carbon dioxide or sulphur dioxide or a liquid organic or inorganic acid, preferably selected from sulphurous acid, alum, phosphoric acid, carbonic acid and hydrochloric acid. Thereby sodium hydroxide as said basic substance and carbon dioxide as said acidic substance are preferred.

[0022] In one embodiment of the invention carbon dioxide is dissolved in an aqueous solution, preferably water, with a gaseous pressure which is typically above 10 bar before said basic substance, preferably sodium hydroxide, is intro-

duced in the aqueous solution. The dissolution of carbon dioxide in an aqueous solution, preferably water, leads to a lowering of the pH value. A controlled addition of sodium hydroxide into the aqueous solution containing dissolved carbon dioxide is a good way for preparing a resulting buffer solution where the pH is below 7.5 all the time. The concentration of bicarbonate ions in the resulting buffer solution and hence its alkalinity can be increased by a successive dissolution of carbon dioxide into the buffer solution and subsequent addition of sodium hydroxide. Advantageously the said aqueous solution contains between 10 and 25 grams, preferably between 16 and 20 grams, carbon dioxide per litre before introducing said basic substance.

[0023] The addition of the said basic substance in parts at several points, preferably where at least one static mixer is placed between said points, could be advantageous in some embodiments of the invention.

[0024] In the prior art the basic substance such as sodium hydroxide is typically fed into the water first to provide an alkaline aqueous solution into which the acidic carbon dioxide is introduced. This is because carbon dioxide dissolves much more quickly in an alkaline solution. In the present invention the carbon dioxide is fed into the water before any basic substance has been introduced. This reversed order of addition ensures a low pH at all times and reduces the precipitation problem of the prior art. Since the final buffer is formed in a reactor, the carbon dioxide has sufficient time in which to dissolve even though the pH is low.

[0025] In another embodiment of the invention there is provided a recirculation of produced buffer solution so that both the basic and acidic additions are made to an aqueous buffer solution having a pH below 7.5. Typically the said basic substance, preferably sodium hydroxide, is introduced to an aqueous solution, preferably water, and the resulting basic solution is mixed with a re-circulated buffer solution keeping the pH of the buffer solution below 7.5. Then the said acidic substance, preferably carbon dioxide, is introduced. It is also possible to add the carbon dioxide to the recirculating buffer solution before the addition of the basic substance. Preferably the said re-circulated buffer solution is a recycle stream from a part of the reactor or from downstream of the reactor. In this embodiment the buffering capacity of the buffer solution is used to keep the pH below 7.5 all the time. The recirculation flow, now buffered by sodium bicarbonate and saturated or over-saturated with carbon dioxide, has a pH below 7.5, preferably between 7.0 and 7.4 depending on the ratio between NaOH and CO₂, and thus fulfils the invention. The possible increase of the pH due to the addition of the basic substance, preferably sodium hydroxide, is compensated by the buffer capacity of the re-circulated buffer solution.

In another embodiment of the invention the pH of the buffer solution is adjusted with an additional portion of the basic substance to a pH above 7.5 after the final addition of the acidic substance. In this embodiment of the invention a buffer solution with a higher pH could be provided to the main process. According to the invention the pH is kept below 7.5 during the buffer production stage and thereby a stable and non-precipitating buffer solution is formed. Afterwards the pH is adjusted to the needs of the main process by the addition of a portion of a basic substance.

[0026] The present invention has one main advantage over the prior art. The precipitation of calcium carbonate in the reactor or similar downstream equipment is significantly reduced. Hence there is less need for using expensive chelating agents or periodic cleaning of the equipment. The profitability of the papermaking process is increased.

[0027] The invention will be described in more detail hereinafter by one embodiment of the invention shown in the figure.

[0028] In the drawing:

Figure 1 shows an embodiment of the invention where a re-circulated buffer solution is used.

[0029] The basic substance, sodium hydroxide, 1 and water 2 are fed together in a mixer 3 to get a diluted sodium hydroxide solution. The amounts of sodium hydroxide and water are controlled to provide a desired concentration of sodium hydroxide in the solution. The acidic substance, carbon dioxide, 4 in the gaseous phase is introduced in the dissolver 5. In the dissolver 5 the gaseous carbon dioxide is dissolved in a re-circulated buffer solution 6. The diluted aqueous solution of sodium hydroxide is fed to the dissolver 5 too. The amount of diluted sodium hydroxide is controlled so as to keep the pH below 7.5. The re-circulated buffer solution 6, which is withdrawn from the reactor 7 and pumped by the pump 8 into the dissolver 5, is buffered by sodium bicarbonate, which is formed in the reactor 7. The carbon dioxide feeding into the buffer solution is adjusted to provide a solution saturated or oversaturated with carbon dioxide. Thereby the pH of the re-circulated buffer solution is according to the invention below 7.5 at all the time when the basic or acidic substances are mixed together. The re-circulated flow of the buffer solution 6 prevents a local increase of the pH above 7.5 due to the introduction of the sodium hydroxide solution. Thereby the precipitation of calcium carbonate is reduced. The pH is always below 7.5 when carbon dioxide is introduced. The sodium bicarbonate containing buffer solution is created in the reactor 7 where bicarbonate ions are formed according the chemical reaction between sodium hydroxide and carbon dioxide mentioned above. The alkalinity and pH of the buffer solution is adjusted to a predetermined value by adjusting the feeds of sodium hydroxide and/ or carbon dioxide. In case a pH above 7.5 is desired in the final buffer solution, the pH may be raised after the final carbon dioxide addition to a pH higher than 7.5 by adding an additional portion of sodium hydroxide. The resulting bicarbonate ions containing buffer solution 9 is supplied to the main process stream, the aqueous pulp suspension, for controlling the alkalinity, pH and/or hardness.

Claims

1. Process for preparing a buffer solution (9) in an industrial papermaking process, wherein the buffer solution (9) is supplied to a main process stream, which is an aqueous pulp suspension or a water stream leading to and/or from said suspension, comprising
 - a) providing a basic (1) and an acidic (4) substance which substances in combination are capable to forming buffering ions which influence the alkalinity of an aqueous medium,
 - b) introducing individually regulated controlled feeds of said basic (1) and said acidic (4) substances as well as water (2) into the reactor (7) of an apparatus located outside the main process stream of said papermaking process,
 - c) causing said basic substance (1) and said acidic substance (4) to react in said water to provide a predefined alkalinity and/or pH in the resulting aqueous buffer solution (9),
 - d) supplying said aqueous buffer solution (9) to said main process stream for controlling the alkalinity, pH and/or hardness in the said process stream, **characterised in that**
 - e) the pH is kept below 7.5 during the whole process of adding said acidic substance (4).
2. Process according to claim 1 wherein said basic substance (1) comprises an alkali metal hydroxide, an alkali metal carbonate, an alkali metal bicarbonate, an alkali metal phosphate, an alkali metal biphosphate and/or an alkali metal phosphite and/or green liquor or white liquor and said acidic substance (4) comprises gaseous carbon dioxide or sulphur dioxide or a liquid organic or inorganic acid, preferably selected from sulphurous acid, alum, phosphoric acid, carbonic acid and hydrochloric acid.
3. Process according to claim 2 wherein said basic substance (1) comprises sodium hydroxide and said acidic substance (4) comprises carbon dioxide.
4. Process according to claim 2 or 3 wherein carbon dioxide (4) is dissolved in an aqueous solution, preferably water, with a gaseous pressure above 10 bar before said basic substance (1), preferably sodium hydroxide, is introduced in the aqueous solution.
5. Process according to claim 4 wherein said aqueous solution contains between 10 and 25 grams, preferably between 16 and 20 grams, carbon dioxide per litre before introducing said basic substance (1).
6. Process according to any one of the claims 2 to 5 wherein said basic substance (1) is added in parts at several points.
7. Process according to claim 6 wherein at least one static mixer is placed between said points.
8. Process according to claim 2 or 3 wherein the said basic substance (1), preferably sodium hydroxide, is introduced to an aqueous solution (2), preferably water, and the basic substance containing aqueous solution is mixed with a re-circulated buffer solution (6), whereby the said acidic substance (4), preferably carbon dioxide, is introduced.
9. Process according to claim 8 wherein said re-circulated buffer solution (6) is a recycle stream from a part of the reactor (7) or from downstream of the reactor (7).
10. Process according to any one of the claims 1 to 9, wherein the pH of said buffer solution (9) is adjusted with an additional portion of said basic substance (1) to a pH above 7.5 after the final addition of said acidic substance (4).

Patentansprüche

1. Verfahren zur Herstellung einer Pufferlösung (9) bei einem technischen Papierherstellungsverfahren, wobei die Pufferlösung (9) einem Hauptprozessstrom, bei dem es sich um eine wässrige Halbstoffsuspension oder einen zu der Suspension führenden und/oder von der Suspension abgehenden Wasserstrom handelt, zugeführt wird, bei dem man
 - a) eine basische (1) und eine saure (4) Substanz bereitstellt, wobei diese Substanzen kombiniert zur Bildung von, puffernd wirkenden Ionen, die die Alkalinität eines wässrigen Mediums beeinflussen, in der Lage sind,
 - b) einzeln regulierte gesteuerte Zulaufströme der basischen (1) und der sauren (4) Substanz sowie Wasser (2)

in den Reaktor (7) einer Apparatur, die sich außerhalb des Hauptprozessstroms des Papierherstellungsverfahrens befindet, einträgt,

c) die basische Substanz (1) und die saure Substanz (4) in dem Wasser zur Bereitstellung einer vordefinierten Alkalinität und/oder eines vordefinierten pH-Werts in der resultierenden wässrigen Pufferlösung (9) zur Reaktion bringt,

d) die wässrige Pufferlösung (9) dem Hauptprozessstrom zur Steuerung der Alkalinität, des pH-Werts und/oder der Härte in dem Prozessstrom zuführt, **dadurch gekennzeichnet, dass** man

e) den pH-Wert während des gesamten Prozesses der Zugabe der sauren Substanz (4) unter 7,5 hält.

2. Verfahren nach Anspruch 1, bei dem die basische Substanz (1) ein Alkalimetallhydroxid, ein Alkalimetallcarbonat, ein Alkalimetallhydrogencarbonat, ein Alkalimetallphosphat, ein Alkalimetallbiphosphat und/oder ein Alkalimetallphosphit und/oder Grünlaug oder Weißlaug umfasst und die saure Substanz (4) gasförmiges Kohlendioxid oder Schwefeldioxid oder eine flüssige organische oder anorganische Säure, vorzugsweise ausgewählt aus schwefliger Säure, Alaun, Phosphorsäure, Kohlensäure und Salzsäure, umfasst.

3. Verfahren nach Anspruch 2, bei dem die basische Substanz (1) Natriumhydroxid umfasst und die saure Substanz (4) Kohlendioxid umfasst.

4. Verfahren nach Anspruch 2 oder 3, bei dem Kohlendioxid (4) in einer wässrigen Lösung, vorzugsweise Wasser, mit einem Gasdruck von mehr als 10 bar gelöst wird, bevor die basische Substanz (1), vorzugsweise Natriumhydroxid, in die wässrige Lösung eingetragen wird.

5. Verfahren nach Anspruch 4, bei dem die wässrige Lösung vor dem Eintragen der basischen Substanz (14) zwischen 10 und 25 Gramm, vorzugsweise zwischen 16 und 20 Gramm, Kohlendioxid pro Liter enthält.

6. Verfahren nach einem der Ansprüche 2 bis 5, bei dem man die basische Substanz (1) in Teilmengen an mehreren Punkten zugibt.

7. Verfahren nach Anspruch 6, bei dem man zwischen den Punkten mindestens einen statischen Mischer anordnet.

8. Verfahren nach Anspruch 2 oder 3, bei dem man die basische Substanz (1), vorzugsweise Natriumhydroxid, in eine wässrige Lösung (2), vorzugsweise Wasser, einträgt und die basische Substanz enthaltende wässrige Lösung mit einer rezirkulierten Pufferlösung (6) mischt, wodurch die saure Substanz (4), vorzugsweise Kohlendioxid, eingeführt wird.

9. Verfahren nach Anspruch 8, bei dem es sich bei der rezirkulierten Pufferlösung (6) um einen Rückführungsstrom aus einem Teil des Reaktors (7) oder einer dem Reaktor (7) nachgeschalteten Stelle handelt.

10. Verfahren nach einem der Ansprüche 1 bis 9, bei dem man den pH-Wert der Pufferlösung (9) nach der letzten Zugabe der sauren Substanz (4) mit einer zusätzlichen Portion der basischen Substanz (1) auf einen pH-Wert von mehr als 7,5 einstellt.

Revendications

1. Procédé de préparation d'une solution tampon (9) dans un procédé industriel de fabrication de papier, dans lequel la solution tampon (9) est apportée dans un flux de procédé principal, qui est une suspension de pâte aqueuse ou un courant d'eau conduisant à et/ou issue de ladite suspension, comprenant les étapes consistant à

a) fournir une substance basique (1) et une substance acide (4), lesquelles substances en combinaison sont capables de former des ions tampon qui influencent l'alcalinité d'un milieu aqueux,

b) introduire des alimentations contrôlées et régulées individuellement de ladite substance basique (1) et de ladite substance acide (4), ainsi que de l'eau (2) dans le réacteur (7) d'un appareil situé hors du flux de procédé principal dudit procédé de fabrication de papier,

c) provoquer la réaction de ladite substance basique (1) et de ladite substance acide (4) dans ladite eau afin de fournir une alcalinité et/ou un pH prédéfini(e) dans la solution tampon (9) aqueuse résultante,

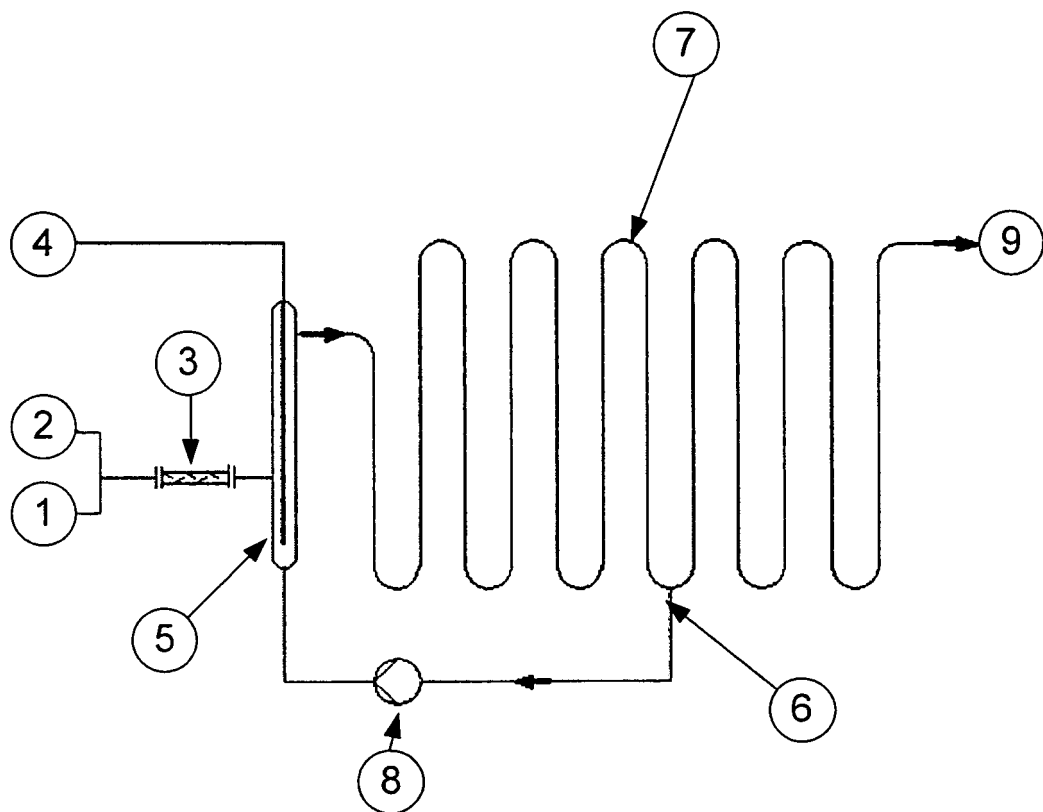
d) apporter ladite solution tampon (9) aqueuse audit flux de procédé principal afin de contrôler l'alcalinité, le pH et/ou la dureté dans ledit flux de procédé,

caractérisé en ce que

e) le pH est maintenu en dessous de 7,5 pendant l'ensemble du procédé d'addition de ladite substance acide (4).

2. Procédé selon la revendication 1, dans lequel ladite substance basique (1) comprend un hydroxyde de métal alcalin, un carbonate de métal alcalin, un bicarbonate de métal alcalin, un phosphate de métal alcalin, un biphosphate de métal alcalin et/ou un phosphite de métal alcalin et/ou une liqueur verte ou une liqueur blanche et ladite substance acide (4) comprend du dioxyde de carbone ou du dioxyde de soufre gazeux ou un acide organique ou inorganique liquide, choisi de préférence parmi l'acide sulfureux, l'alun, l'acide phosphorique, l'acide carbonique et l'acide chlorhydrique.
3. Procédé selon la revendication 2, dans lequel ladite substance basique (1) comprend de l'hydroxyde de sodium et ladite substance acide (4) comprend du dioxyde de carbone.
4. Procédé selon la revendication 2 ou 3, dans lequel le dioxyde de carbone (4) est solubilisé dans une solution aqueuse, préférentiellement de l'eau, avec une pression gazeuse supérieure à 10 bars avant l'introduction de ladite substance basique (1), préférentiellement de l'hydroxyde de sodium, dans la solution aqueuse.
5. Procédé selon la revendication 4, dans lequel ladite solution aqueuse contient entre 10 et 25 grammes, préférentiellement entre 16 et 20 grammes, de dioxyde de carbone par litre avant l'introduction de ladite substance basique (1).
6. Procédé selon l'une quelconque des revendications 2 à 5, dans lequel ladite substance basique (1) est ajoutée en parties à plusieurs points.
7. Procédé selon la revendication 6, dans lequel au moins un mélangeur statique est placé entre lesdits points.
8. Procédé selon la revendication 2 ou 3, dans lequel ladite substance basique (1), préférentiellement de l'hydroxyde de sodium, est introduite dans une solution aqueuse (2), préférentiellement de l'eau, et la solution aqueuse contenant la substance basique est mélangée avec une solution tampon (6) recirculée, ce par quoi ladite substance acide (4), préférentiellement du dioxyde de carbone, est introduite.
9. Procédé selon la revendication 8, dans lequel ladite solution tampon (6) recirculée est un courant de recirculation issue d'une partie du réacteur (7) ou d'une partie en aval du réacteur (7).
10. Procédé selon l'une quelconque des revendications 1 à 9, dans lequel le pH de ladite solution tampon (9) est ajusté par une portion supplémentaire de ladite substance basique (1) jusqu'à un pH supérieur à 7,5 avant l'addition finale de ladite substance acide (4).

Figure 1



REFERENCES CITED IN THE DESCRIPTION

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