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(54) CLEANING FOULING FROM A DECANTER

(57) A method (10) of cleaning a decanter from fouling that is present on an inside of the decanter, the method comprising: feeding (12) hydrogen peroxide (H_2O_2) into the decanter such that the H_2O_2 contacts the fouling; feeding (13) sodium hydroxide (NaOH) into the decanter, for allowing the NaOH to react with H_2O_2 that is in contact with the fouling and/or has penetrated into the fouling, to thereby clean the decanter, and feeding (14) water into the decanter, to thereby rinse the decanter.

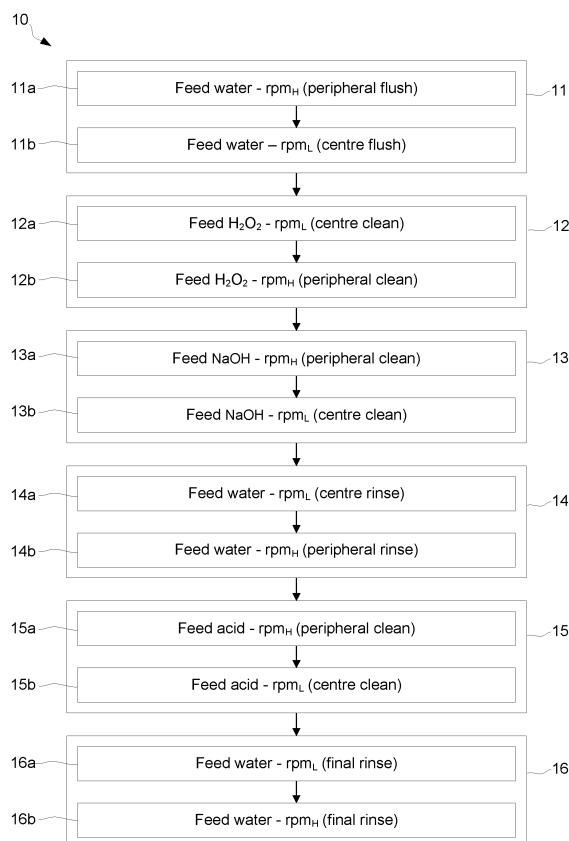


Fig. 2

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Description

Technical Field

[0001] The invention relates to a method of cleaning a decanter from fouling that is present on an inside of the decanter. The method is typically used when the fouling comprises fibers and/or proteins that come from oats or from another plant-based material.

Background

[0002] Today, the food industry's shift towards plant-based food products is propelled by growing awareness of health benefits and environmental concerns. These products often contain fibers crucial for texture and nutritional content. However, separating fibers from the liquid phase is necessary in various applications to ensure appealing product qualities. Decanter centrifuges, also referred to as decanters, have emerged as a standard solution for this separation process due to their ability to preserve product quality and nutritional attributes.

[0003] However, the operation of decanters leads to the accumulation of fouling, which can degrade machine performance and product quality over time. Proper cleaning is important to maintain efficient operation and consistent product attributes. The conventional approach to cleaning decanters involves a clean-in-place (CIP) technique, wherein cleaning agents and processes are passed through the decanter to remove accumulated contaminants and residues from the decanter's interior surfaces.

[0004] While conventional CIP techniques successfully clean decanters, they often demand substantial time and energy resources. For instance, the cleaning process can extend from 3 to 4 hours, making it a time-consuming operation. In plant-based food production processes, the decanter's extended cleaning time can become a bottleneck, slowing down the overall food-making process. In addition, some conventional CIP techniques can leave fouling residue in the machine, which could lead to microbial concerns.

[0005] Thus, there exists a need for innovative solutions that can address the shortcomings of, or at least improve, CIP techniques that are used for cleaning decanters. Thus is true in particular when cleaning decanters that have been used for separating fibers from a plant-based food product, where the liquid phase is subsequently used for producing the final food product.

Summary

[0006] It is an object of the invention to at least partly overcome one or more of the above-identified limitations of the prior art. One such object is to provide a method of cleaning a decanter from fouling that is present on an inside of the decanter. The method should preferably be efficient in cleaning fouling that comprises fibers and/or

proteins that are derived from oats or from another plant-based material.

[0007] One or more of these objectives, as well as further objectives that may appear from the aspects and the description below, are at least partly achieved by a method of cleaning a decanter from fouling according to the independent claims, embodiments thereof being defined by the dependent claims.

[0008] A first aspect relates to a method for cleaning a decanter from fouling that is present on an inside of the decanter. The method comprises feeding hydrogen peroxide (H_2O_2) into the decanter such that the H_2O_2 contacts the fouling; feeding sodium hydroxide (NaOH) into the decanter, for allowing the NaOH to react with H_2O_2 that is in contact with the fouling and/or has penetrated into the fouling, to thereby clean the decanter; and feeding water into the decanter, to thereby rinse the decanter.

[0009] When the hydrogen peroxide reacts with the sodium hydroxide, a chemical reaction occurs that produces water (H_2O) and sodium peroxide (Na_2O_2). The reaction can be represented by the following balanced chemical equation: $2H_2O_2 + 2NaOH \rightarrow 2H_2O + Na_2O_2$. The reaction happens through a, exothermic process that involves so called decomposition. It has been seen that the fouling is efficiently broken down when this reaction happens on the surface of fouling. If the fouling has absorbed some of the hydrogen peroxide, which is often the case, the subsequent reaction with the sodium hydroxide also causes the fouling to "explode" or disintegrate from within.

[0010] The Applicant has spent considerable research efforts on finding ways of improving the cleaning of decanters, and has found that efficient cleaning can be accomplished by the "exploding" or the disintegration of the fouling from within, as described above. As a result, time and resources required for successfully and safely cleaning a decanter have been reduced.

[0011] In some embodiments, the method comprises feeding water into the decanter before the feeding of H_2O_2 , to thereby flush the decanter. This efficiently removes fouling that does not stick or adhere to the inside of the decanter, thereby decreasing the amount of hydrogen peroxide and sodium hydroxide required for accomplishing efficient cleaning.

[0012] In some embodiments, the method comprises feeding acid into the decanter after the feeding of water for rinsing the decanter, to thereby accomplish cleaning.

[0013] In some embodiments, the method comprises feeding water into the decanter after the feeding of acid, to thereby rinse the decanter.

[0014] In some embodiments, the feeding of H_2O_2 comprises circulating, via an outlet of the decanter to an inlet of the decanter, the H_2O_2 over the decanter, and the feeding of NaOH comprises circulating, via the outlet of the decanter to the inlet of the decanter, the H_2O_2 over the decanter.

[0015] In some embodiments, the feeding of H_2O_2 comprises rotating an interior bowl of the decanter at a

first rotational speed during a first period of time, and rotating the interior bowl at a second rotational speed for a second period of time, the first rotational speed differing from the second rotational speed at least by a factor 2, or at least by a factor 3.

[0016] In some embodiments, the feeding of NaOH comprises rotating the interior bowl at a third rotational speed during a third period of time, and rotating the interior bowl at a fourth rotational speed for a fourth period of time, the third rotational speed differing from the fourth rotational speed at least by a factor 2, and the third rotational speed differing from the second rotational speed by a factor of at most 0.8.

[0017] In some embodiments, the first rotational speed is selected to cause a g-force in the range of 1.2 to 1.6 g for H₂O₂ that is located at a rotational periphery of the bowl.

[0018] In some embodiments, the second rotational speed is higher than the first rotational speed, and is at least 3000 rpm.

[0019] In some embodiments, the H₂O₂ has a temperature in the range of 50 to 70 °C, and/or the NaOH has a temperature in the range of 50 to 90 °C.

[0020] In some embodiments, the feeding of H₂O₂ is performed for a period of time that is in the range of 10 to 40 minutes, and/or the feeding of NaOH is performed for a period of time that is in the range of 40 to 90 minutes.

[0021] In some embodiments, the H₂O₂ has a concentration of 0.2 to 1.0 %, and/or the NaOH has a concentration of 0.6 to 2.5 %. In some embodiments, the acid has a concentration of 0.8 to 1.2 %.

[0022] The embodiments described above, pertaining to using water, acid and recirculation, as well as using rotational speeds, temperatures, times and concentration levels as indicated above contribute to, both individually and collectively, fast and resource-efficient cleaning of a decanter. The applicant has found this after performing systematic and considerable research efforts, using steps and operational cleaning conditions that hereto has been unknown in the context of cleaning decanters.

[0023] In some embodiments, the fouling comprises fibers and/or proteins that are derived from oats, or derived from another plant-based material.

[0024] The method is then particularly advantageous, as it has been seen that fouling from oats relatively quickly and thoroughly absorbs hydrogen peroxide, making the subsequent reaction with the sodium hydroxide more efficient. This realization came from tests directed to investigating the propensity of hydrogen peroxide to "adhere" to oat prolamins that is present in the fouling, and how the fouling could then be "exploded" by causing a reaction between the hydrogen peroxide and the sodium hydroxide. Tests were also successfully performed on fouling from other plant-based materials that have high glutamine and proline contents, which typically have poor solubility in water. This included fouling from plant-based materials such as wheat, barley, rye and corn.

[0025] The method for cleaning a decanter is therefore particularly beneficial in connection with plant-based beverage production, in particular oat based beverage production, where decanters commonly are used and must be regularly cleaned.

[0026] Still other objectives, features, embodiments, and aspects, as well as additional features and advantages will appear from the following detailed description as well as from the accompanying schematic drawings.

Drawings

[0027]

- Fig. 1 is a schematic view of a decanter.
Fig. 2 is a flow diagram of a method for cleaning a decanter.

Description

[0028] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments are shown. Indeed, the subject of the present disclosure may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure may satisfy applicable legal requirements.

[0029] Where possible, any of the advantages, features, functions, devices, and/or operational aspects of any of the embodiments described and/or contemplated herein may be included in any of the other embodiments described and/or contemplated herein, and/or vice versa. In addition, where possible, any terms expressed in the singular form herein are meant to also include the plural form and/or vice versa, unless explicitly stated otherwise. Accordingly, the terms "a" and/or "an" shall mean "at least one" or "one or more", even though the phrase "one or more" or "at least one" is also used herein. The terms "multiple", "plural" and "plurality" are intended to imply provision of two or more elements. The term "and/or" includes any and all combinations of one or more of the associated listed elements. Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing the scope of the present disclosure.

[0030] Well-known functions or constructions may not be described in detail for brevity and/or clarity. Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs.

[0031] Like reference signs refer to like elements throughout.

[0032] As used herein, "fouling" are residues from a product that remains on the inside of a decanter, after the decanter has been used for separating solids, such as particles or fibers, from a product.

[0033] As used herein, "hydrogen peroxide" is a mixture of the chemical compound with the formula H_2O_2 and water. Thus, it is a dilute solution (for example up to 10% by weight) in water, typically for use in industry such as in the food processing industry.

[0034] As used herein, "sodium hydroxide" is a mixture of the chemical compound with the formula NaOH and water. Thus, it is a dilute solution (for example up to 20% by weight) in water, typically for use in industry such as in the food processing industry.

[0035] As used herein, "acid" is a mixture of acid and water. Thus, it is a dilute solution (for example up to 20% by weight). Examples of acids include hydrochloric acid, nitric acid, citric acid, and any other acid that is suitable for cleaning equipment that is used in the industry, in particular in the food processing industry.

[0036] As used herein, "concentration" is the concentration in weight percent (% w/w). Thus, it is a measure of the weight of the respective solute (H_2O_2 , NaOH or acid) as a percentage of the total weight of the solution. For example, a 10% concentration of NaOH would have 10 grams of sodium hydroxide in 100 grams of solution, where the remaining part of the solution is water (90 grams of water).

[0037] Fig. 1 illustrates centrifugal decanter 20, referred to as decanter, which is arranged for solid-liquid separation of a plant-based slurry that contains liquid and fibers. The plant-based slurry may have been produced by milling and mixing a plant product with water. The plant product may be any suitable type of grains, seeds, nuts and legumes, such as but not limited to almonds, cashews, macadamias, coconuts, soybeans, hemp seeds, quinoa, rice, wheat, barley, rye corn and oats. In many cases enzymes are added to the slurry to break down the plant product into a more soluble form and decompose the starch. The slurry is thereafter treated to remove insoluble fibers, mixed with additional water and flavor agent, homogenized, pasteurized/UHT sterilized, and finally packed into a package.

[0038] The decanter 20 is operable to perform the removal of insoluble fibers by receiving the slurry via an inlet 21, separating the slurry into its liquid and solid phases, with the liquid phase being discharged through one outlet 29 and the solid phase, containing fibers, being discharged through another outlet 35. The outlet 29 for the liquid is referred to as a liquid outlet while the outlet 35 for the solids is referred to as a solids outlet 35. This separation process is achieved through the application of centrifugal force, leveraging the density differences between the phases and the principles of sedimentation and clarification.

[0039] This inlet 21 is equipped with a feed tube 22 that helps to evenly distribute the slurry into a scroll 25. The scroll 25 is a spiral-shaped conveyor that transports and

dewaters the solids in the slurry. The scroll 25 has flights 26 arranged along its outer surface, giving the scroll the shape of a hollow, spiral screw conveyor. The flights 26 act as paddles, pushing and conveying the solid particles toward a conical section 30a of the scroll 25, where dewatering occurs. As used herein, dewatering refers to the removal of liquid from the slurry, to thereby create the liquid phase and the solid phase.

[0040] A bowl 32, having a cylindrical main body 32b with a conical end 32a, houses the scroll 25 and all its associated components. The slurry is introduced into the bowl 32, in an interspace 37 formed between the scroll 25 and the bowl 32. The slurry enters the interspace 37 via two outlets 24a, 24b at a distal end of the feed tube 22. To facilitate even distribution of slurry out through the outlets 24a, 24b, the scroll 25 has a hollow space 23 at the end of the feed tube 22. The slurry passes from this space 23, through the outlets 24a, 24b and into the bowl 32.

[0041] The bowl 32 is arranged to rotate about its longitudinal axis. Due to this rotating motion, the heavier solid particles migrate outward toward the bowl wall, i.e. toward the rotational periphery 31 of the bowl 32, under the influence of centrifugal force. The bowl's shape promotes sedimentation and separation of the solid and liquid phases.

[0042] The scroll 25 has a cylindrical section 30b that is responsible for initial solid-liquid separation. As the bowl 32 spins, the centrifugal force causes the heavier solids to move toward the outer periphery 31 of the bowl, while the lighter liquid phase moves toward the center. This initial separation sets the stage for further dewatering.

[0043] The scroll 25 has a conical section 30a that is located at the solid outlet 35 of the decanter 20. This conical section 30a is designed to facilitate the dewatering of the solid phase. As the scroll 25 rotates within the bowl 32, the angle of the conical section and the decreasing volume of space force the solid particles, now having lower liquid content, to compress and compact. This action expels additional liquid from the solids, enhancing the dewatering process.

[0044] The bowl 32 has two outlets. The first outlet is a solid phase outlet 34a, 34b that is located at the end of the conical end 32a, which passes the solid phase further to the solid outlet 35 of the decanter 20. The slurry can be passed to a drain 45, or can be used for any other suitable purpose. The second outlet is a liquid phase outlet 28a, 28b that is located at the end of the cylindrical main body 32b, which passes the liquid phase further to the liquid outlet 29 of the decanter 20. The two outlets 34a, 34b respectively 28a, 28b are located at opposite end of the bowl 32.

[0045] To contain the entire process and ensure safety, the bowl 32 and its internal components, which includes the scroll 25, are enclosed within a casing 80. This casing 80 prevents any potential hazards from the high-speed spinning of the bowl 32. An interior space 38 is typically formed between the bowl 32 and the casing 80.

[0046] The operation of the decanter 20 involves sev-

eral steps that exploit the principles of centrifugation, sedimentation, and dewatering. First, the slurry, consisting of liquid and solid phases with fibers in slurry, is introduced through the inlet 21 and feed tube 22. The feed tube 22 ensures an even distribution of the slurry onto the scroll 25, into the hollow space 23 inside the scroll 25. As the bowl 32 starts to rotate at high speeds, typically driven by an electric motor, the centrifugal force pushes the solid particles towards the bowl's wall, that is to the rotational periphery 31 of the bowl 32. This initial separation between the liquid and solid phases occurs at the cylindrical section 30a of the scroll 25.

[0047] The scroll 25 is driven by a motor to rotate, such that the flights 26 on the scroll's outer surface transport the solids along the spiral path toward the conical section 30a. It may, via a gearbox, be driven by the same motor as the bowl 32. At the conical section 30a, the decreasing volume of space and the compaction action exerted by the scroll's flights force the solids to compress. This compression results in the expulsion of additional liquid from the solids, further concentrating the solid phase.

[0048] The separated liquid phase, located toward the center of the bowl due to its lower density, is directed to the liquid outlet 28a, 28b of the bowl 32. Simultaneously, the dewatered solid phase, which has accumulated in the conical section, is expelled through the solid outlet 34a, 34b of the bowl 32. From there the phases exit the entire decanter 20 through the decanter outlets 35, 29. As long as the slurry is fed into the inlet 21, and the motor maintains the bowl's and scroll's rotation, the separation process continues. This continuous operation is beneficial in food applications that require efficient and consistent separation of fibers from a plant-based slurry.

[0049] During operation fouling occurs on the inside of the decanter 20. This includes the inside 37, also referred to as interspace 37, formed between the scroll 25 and the bowl 32, and the inside 38, also referred to as interior space 38, formed between the bowl 32 and the casing 80. Other inside sections of the decanter include the inner side of the feed tube 22, the hollow space 23 in the scroll 25, plus all other sections inside the decanter where the slurry, liquid phase and/or the solid phase come into contact with different parts and sections of the decanter 20. Examples of fouling particles are schematically illustrated in Fig. 1, see reference numerals 39a-39e.

[0050] When operation of the decanter 20 is complete, a cleaning process is required for removing fouling 39a-39e. This is important not only for managing the decanter's performance, but also for assuring that sanitary conditions can be maintained. The cleaning of the decanter involves a clean-in-place (CIP) technique, which includes cleaning agents being passed through the decanter to remove accumulated fouling from the decanter's interior surfaces.

[0051] Basically, the CIP for the decanter 20 involves passing CIP liquids through the decanter 20 according to a specific method for cleaning the decanter 20. Such method is described below and may generally be referred

to as "CIP", or "CIP method". The CIP method is performed by feeding various CIP liquids into the inlet 21, letting them pass through the decanter 20 and out from the outlets 29, 35. A majority of the CIP liquid is passed out from the liquid outlet 29 and recirculated back into the inlet 21.

[0052] Several components are connected to the decanter 20 for facilitating the CIP method. For example, a circulation conduit 64 is connected between the liquid outlet 29 and the inlet 21 of the decanter 20. Part of the circulation conduit 64 may be formed by a first section 81 that is closest to the liquid outlet 29. A pump 65 is arranged in the first section, and a first valve 82 is arranged downstream of the pump 65 for pumping a liquid phase through an output line 83, or for pumping CIP liquid further into the circulation conduit 64. Thus, when the decanter 20 is operated to separate a slurry to a liquid phase and a solid phase, the liquid phase may exit through the outlet 29, pass through the first section 81 and, by setting the first valve 82 accordingly, further to the output line 83. When the decanter 20 is operated for performing a CIP method, the CIP liquid phase may exit through the outlet 29, pass through the first section 81 and, by setting the first valve 82 accordingly, further into the circulation conduit 64.

[0053] The circulation conduit 64 comprises, in downstream order, a second valve 66, a third valve 68a, a fourth valve 68b and a fifth valve 62. The second valve 66 can route CIP liquid further down the circulation conduit 64, alternatively or additionally route the CIP liquid back to a number of CIP sources 41-44 or to a container 75 for used CIP liquid, as will be described later on. The third valve 68a can convey CIP liquid to a first nozzle 69a that is arranged on the inside of the casing 80. The first nozzle 69a is arranged to spray the interior space 38 between the bowl 32 and the casing 80. Fouling in this space 38 can thereby be removed.

[0054] The fourth valve 68b can convey CIP liquid to a second nozzle 69b that is arranged on the inside of the casing 80. The second nozzle 69b is also a nozzle that sprays the interior space 38 between the bowl 32 and the casing 80, but at different places as compared to the first nozzle 69b, to thereby allow for the entire interior space 38. Further nozzles may be arranged for spraying the interior space 38 between the bowl 32 and the casing 80.

[0055] The CIP liquid sprayed by the nozzles 69a, 69d eventually flow down to the bottom of the bowl 80. The bottom of the bowl 80 may be inclined towards the outlet 29 for the liquid phase, allowing liquid to flow from the bottom of the casing 80, towards and into the liquid outlet 29 such that it can be re-introduced in the circulation conduit 64. A major portion of the CIP liquid in the circulation conduit 64 enters the fifth valve 62 where it is routed to the inlet 21 of the decanter 20. This completes the recirculation of CIP liquid over the decanter 20.

[0056] The CIP liquid fed into the decanter 20 is initially drawn from a number of CIP sources 41-44. This includes a first CIP source 41 filled with water. A second CIP

source 42 is filled with acid, such as nitric acid, hydrochloric acid or citric acid. A third CIP source 43 is filled with hydrogen peroxide (H_2O_2), while a fourth CIP source 44 is filled with lye, also referred to as sodium hydroxide (NaOH). The acid, H_2O_2 and NaOH are typically diluted with water to desired concentrate levels, as will be described below. As used herein, acid may therefore refer to water having a certain concentration of acid, H_2O_2 may refer to water having a certain concentration of H_2O_2 , and NaOH may refer to water having a certain concentration of NaOH. As used herein, water, acid, H_2O_2 and NaOH from the CIP sources 41-44 may be referred to a CIP liquids.

[0057] Four pumps 51-54, one for the respective CIP liquid, are used to pump the CIP liquids into a CIP supply conduit 61. The CIP supply conduit 61 is connected to the fifth valve 62. The fifth valve 62 is controllable to route the CIP liquids into the circulation conduit 64. From there the CIP liquid is fed into the decanter 20. CIP liquids can therefore be supplied in desired amounts into the decanter 20. When the desired amount has been reached, the fifth valve 62 is closed for preventing further introduction of CIP liquid from the CIP supply conduit 61. The CIP liquid may thereafter be circulated over the supply conduit 61 and the decanter 20 for as long as is needed.

[0058] When a CIP liquid has been used as desired for cleaning the decanter 20, which typically includes circulating the CIP liquid over the decanter 20 via the supply conduit 64 by controlling valves 62, 82, 66, 68a and 68b accordingly, it may be re-introduced back into its CIP source, alternatively into the container 75 where partly used CIP liquid may be stored. For this purpose, a CIP recovery line 67 may be connected to the second valve 66. The CIP recovery line 67 has four valves, denoted by reference numerals 71, 72, 73 and 74. These valves 71-74 are operable to direct the respective CIP liquid to the CIP source it originally came from, alternatively directing it the container 75 for used CIP liquid. The container 75 for used CIP liquid may comprise several sub-containers that are arranged to store different types of used CIP liquid separate from each other.

[0059] With reference to Fig. 2, a flow diagram of a method 10 for cleaning a decanter is illustrated. The method 10 can be performed for efficiently cleaning a decanter like the decanter 20 previously described. The method, when performed, address the issue of fouling 39a-d on the interior surfaces 37, 38 of the decanter 20. This fouling 39a-d is commonly composed of fibers and proteins, typically derived from oats or other plant-based materials.

[0060] The cleaning method includes the feeding 12 of H_2O_2 into the decanter 20. The purpose of this step is to ensure that the H_2O_2 comes into direct contact with the fouling 39a-d, initiating the cleaning action. To facilitate thorough coverage, the H_2O_2 is circulated from the decanter's outlet 29 back to its inlet 21. This circulation ensures that all areas of the decanter affected by fouling are reached by the H_2O_2 .

[0061] Following the H_2O_2 treatment, NaOH is introduced 13 into the decanter 20. The objective here is for the NaOH to react with the H_2O_2 , particularly in areas where the H_2O_2 has contacted and/or penetrated the fouling 39a-d. This reaction is crucial for effectively breaking down the fouling, thereby cleaning the interior surfaces 37, 38 of the decanter 20. The NaOH is circulated in a similar manner as the H_2O_2 , moving from the outlet 29 to the inlet 21 of the decanter. The NaOH is circulated after the H_2O_2 has completed its circulated through the decanter 20, and has been fed back to its original source or to a container for used H_2O_2 .

[0062] An aspect of this method involves controlling the rotational speeds of the decanter's bowl 32 during the treatments with H_2O_2 respectively NaOH. Initially, during the H_2O_2 feeding 12, the bowl 32 is rotated at a first specific rotational speed (rpm_H ; rpm_L) for a predetermined first period of time. This speed is then altered to a second rotational speed (rpm_H ; rpm_L) for a second period of time, with the second speed being at least a factor of 2, 3, 4, or 5 different from the first speed. This means that the first rotational speed may be 2, 3, 4, or 5 times larger than the second rotational speed, or may be 2, 3, 4, or 5 smaller than the second rotational speed. The important thing is that the speeds are different, as it has been shown that a higher rotational speed is more efficient in cleaning peripheral parts of the bowl 32, while a lower rotational speed is more efficient in cleaning parts of the bowl 32 that are relatively closer to its center axis.

[0063] When feeding 13 NaOH, the method 10 may involve rotating the bowl at a third rotational speed (rpm_H ; rpm_L) during a third period, followed by a fourth rotational speed (rpm_H ; rpm_L) for a fourth period. The third speed is distinct from the fourth by at least a factor of 2, and it differs from the second speed by a factor of no more than 0.8.

[0064] The selection of the first rotational speed may be tailored to generate a specific g-force, ranging between 1.2 to 1.6 g, particularly impacting the H_2O_2 located at the rotational periphery 31 of the bowl 32. The generate specific g-force may be calculated by using the conventional formula $g = (r \times \omega^2) / g_0$, where g is the g-force, r is the distance from the center of the bowl to its internal periphery, ω is the angular velocity of the bowl, and g_0 is the standard acceleration due to gravity (approximately 9.81 m/s^2).

[0065] The second rotational speed may be set higher than the first rotational speed, with a minimum threshold of 3000 rpm, to augment the distribution and effectiveness of the cleaning agents within the decanter.

[0066] Prior to introducing H_2O_2 , the method may include a preliminary flushing stage where water is fed 11 into the decanter 20 to pre-clean or flush the interior 37, 38. Subsequent to the chemical treatments with H_2O_2 and NaOH, a rinsing step may be employed, involving feeding 14 water into the decanter 20 to remove any residual chemicals.

[0067] In some embodiments, an acid with a concen-

tration ranging from 0.8 to 2.2% is fed 15 into the decanter 20 following the water rinse 13, providing an additional cleaning action. A subsequent water rinse 16 may then be conducted to ensure complete removal of all cleaning agents and residues.

[0068] Temperature control is conducted as a part of the method 10. The H_2O_2 is preferably maintained at a temperature between 50 to 70 °C. The temperature of the NaOH may be kept between 50 to 90 °C. These specific temperature ranges are used for optimizing the chemical reactivity and cleaning efficacy. The duration of feeding 12 H_2O_2 may be performed within a period of 10 to 40 minutes, and the feeding 13 of NaOH may be performed within a period of 40 to 90 minutes. Furthermore, the concentrations of the chemical agents may be carefully chosen, with H_2O_2 concentration maintained between 0.2 to 1.0%, while the NaOH concentration may be kept within the range of 0.6 to 2.5%.

[0069] As indicated, each of the CIP liquids may, when performing the method 10, be fed through the decanter 20 while the bowl 32 of the decanter 20 is rotated at different rotational speeds, herein referred to as feeding the CIP liquid at different rotational speeds.

[0070] Specifically, the feeding 11 of water may comprise feeding 11a water at a first, higher rotational speed rpm_H , and a thereafter feeding 11b water at a second, lower rotational speed rpm_L . The subsequent feeding 12 of H_2O_2 may comprise feeding H_2O_2 12a at a first, lower rotational speed rpm_L , and a thereafter feeding 12b H_2O_2 at a second, higher rotational speed rpm_H . The subsequent feeding 13 of NaOH may comprise feeding NaOH 13a at a first, higher rotational speed rpm_H , and a thereafter feeding 13b NaOH at a second, lower rotational speed rpm_L . The subsequent feeding 14 of water may comprise feeding water 14a at a first, lower rotational speed rpm_L , and a thereafter feeding 14b water at a second, higher rotational speed rpm_H . The subsequent feeding 15 of acid may comprise feeding acid 15a at a first, higher rotational speed rpm_H , and a thereafter feeding 15b acid at a second, lower rotational speed rpm_L . The final feeding 16 of water may comprise feeding water 16a at a first, lower rotational speed rpm_L , and a thereafter feeding 16b water at a second, higher rotational speed rpm_H .

[0071] Herein, a lower rotational speed rpm_L means rotating the bowl with a lower rotational speed as compared with rotating it with the higher rotational speed rpm_H . The difference between the higher and lower rotational speed is typically a factor 2, 3, 4, or 5.

[0072] Instead of having the pattern of rotational speeds as described in connection with Fig. 2, the order of the rotational speeds may be reversed when feeding the respective CIP liquid. However, it is preferably reversed for all feeding steps, such that feeding of a subsequent (the next) CIP liquid starts with the bowl rotating with the same speed, or substantially with the same speed, as the speed used at the end of the feeding of the previous CIP liquid. This accomplishes more efficient

cleaning and saves energy as it reduces the need of adjusting the rotational speed, while still ensuring that two different speeds are used for obtaining efficient cleaning of both the center and the periphery of the bowl.

[0073] The method 10 comprehensively addresses the challenge of cleaning fouling 39a-d in the decanter 20 by employing a sequential and controlled introduction of specific chemical agents, combined with strategic rotational speeds and temperature management, ensuring effective and efficient cleaning of fouling, particularly of the type comprising fibers and/or proteins from plant-based materials.

15 Claims

1. A method (10) of cleaning a decanter (20) from fouling (39a-d) that is present on an inside (37, 38) of the decanter (20), the method (10) comprising:

feeding (12) hydrogen peroxide (H_2O_2) into the decanter (20) such that the H_2O_2 contacts the fouling (39a-d),

feeding (13) sodium hydroxide (NaOH) into the decanter (20), for allowing the NaOH to react with H_2O_2 that is in contact with the fouling (39a-d) and/or has penetrated into the fouling (39a-d), to thereby clean the decanter (20), and feeding (14) water into the decanter (20), to thereby rinse the decanter (20).

2. The method according to claim 1, comprising feeding (11) water into the decanter (20) before the feeding (12) of H_2O_2 , to thereby flush the decanter (20).
3. The method according to any preceding claim, comprising feeding (15) acid into the decanter (20) after the feeding (14) of water for rinsing the decanter (20), to thereby accomplish cleaning.
4. The method according to claim 3, comprising feeding (16) water into the decanter (20) after the feeding (15) of acid, to thereby rinse the decanter (20).
5. The method according to any preceding claim, wherein the

the feeding (12) of H_2O_2 comprises circulating, via an outlet (29) of the decanter (20) to an inlet (21) of the decanter (20), the H_2O_2 over the decanter (20), and

the feeding (13) of NaOH comprises circulating, via the outlet (29) of the decanter (20) to the inlet (21) of the decanter (20), the H_2O_2 over the decanter (20).

6. The method according to any preceding claim,
wherein the
the feeding (12) of H_2O_2 comprises rotating a bowl
(32) of the decanter (20) at a first rotational speed
(rpm_H; rpm_L) during a first period of time, and rotating 5
the bowl (32) at a second rotational speed (rpm_H;
rpm_L) for a second period of time, the first rotational
speed differing from the second rotational speed at
least by a factor 2. 10
7. The method according to claim 6, wherein the
the feeding (12) of NaOH comprises rotating the
bowl (32) at a third rotational speed (rpm_H; rpm_L)
during a third period of time, and rotating the interior
bowl (32) at a fourth rotational speed (rpm_H; rpm_L) 15
for a fourth period of time, the third rotational speed
differing from the fourth rotational speed at least by a
factor 2, and the third rotational speed differing from
the second rotational speed by a factor of at most 0.8. 20
8. The method according to claim 6 or 7, wherein the
first rotational speed is selected to cause a g-force in
the range of 1.2 to 1.6 g for H_2O_2 that is located at a
rotational periphery (31) of the bowl (32). 25
9. The method according to any one of claims 6 - 8,
wherein the second rotational speed is higher than
the first rotational speed, and is at least 3000 rpm.
10. The method according to any preceding claim, 30
wherein the H_2O_2 has a temperature in the range
of 50 to 70 °C, and/or the NaOH has a temperature in
the range of 50 to 90 °C.
11. The method according to any preceding claim, 35
wherein
the feeding (12) of H_2O_2 is performed for a
period of time that is in the range of 10 to 40
minutes, and/or 40
the feeding (13) of NaOH is performed for a
period of time that is in the range of 40 to 90
minutes.
12. The method according to any preceding claim, 45
wherein the H_2O_2 has a concentration of 0.2 to 1.0
%, and/or the NaOH has a concentration of 0.6 to 2.5
%.
13. The method according to claim 3, wherein the acid 50
has a concentration of 0.8 to 2.2 %.
14. The method according to any preceding claim,
wherein the fouling (39a-d) comprises fibers and/or
proteins that are derived from oat or derived from 55
another plant-based material.

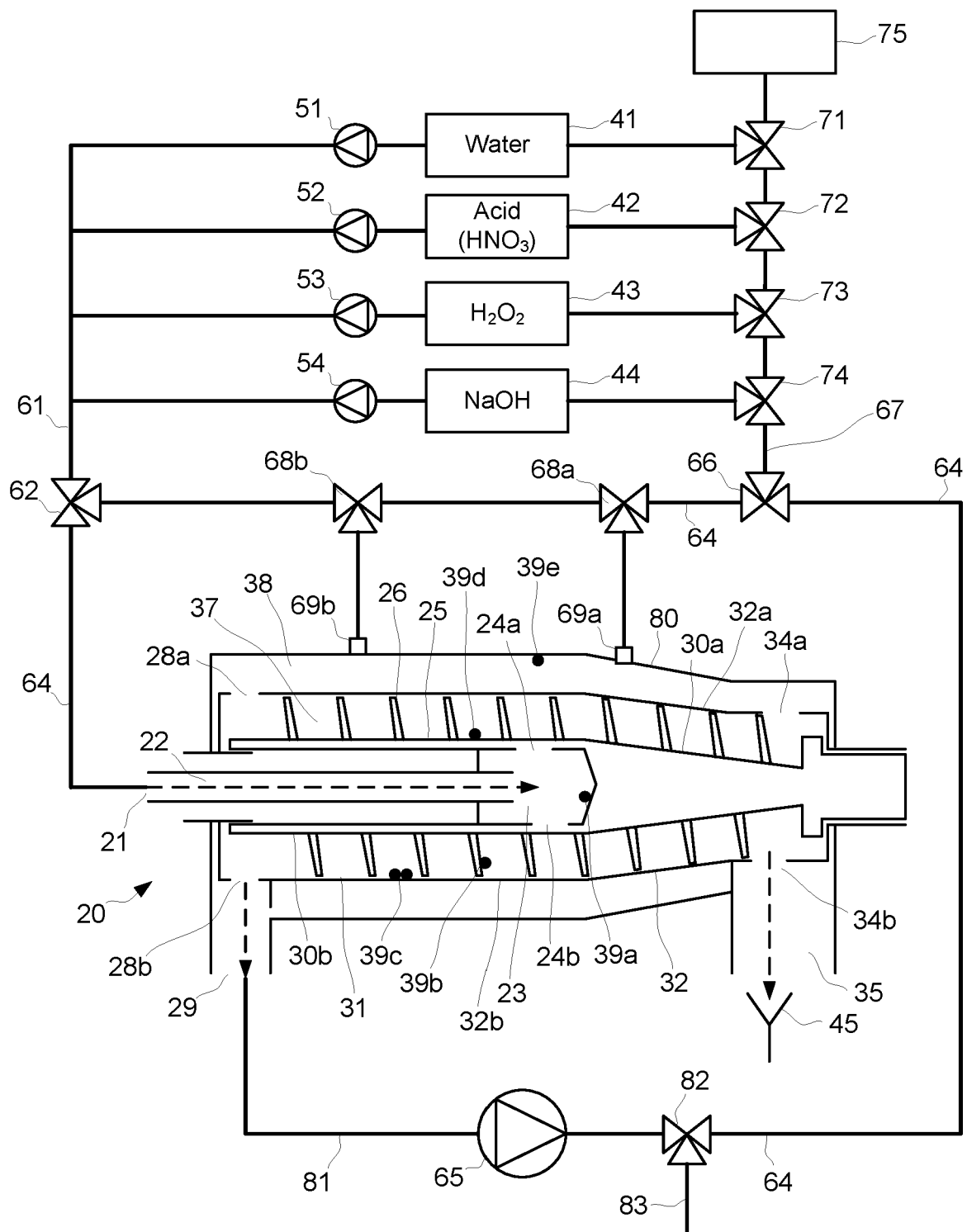


Fig. 1

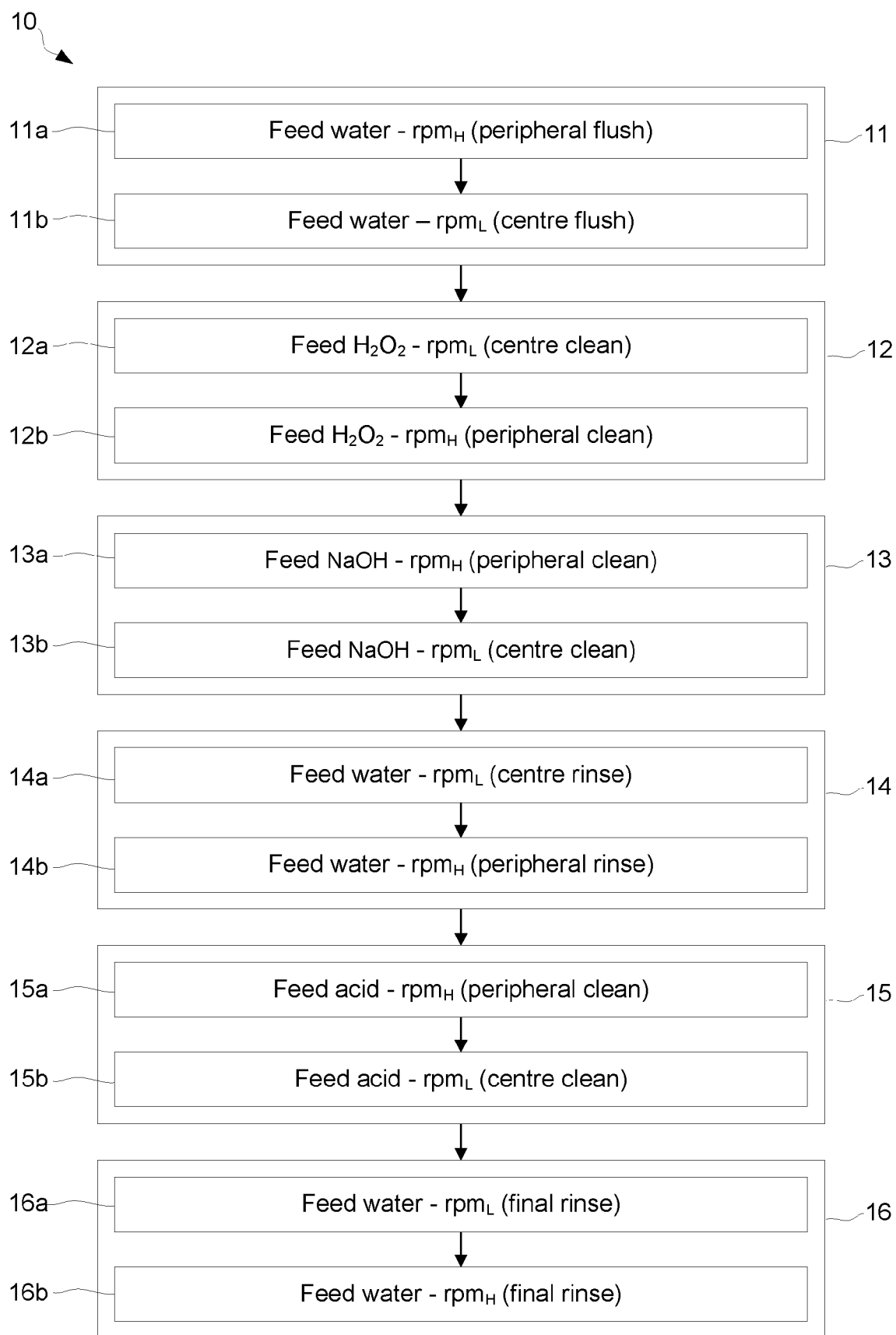


Fig. 2



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Place of search The Hague		Date of completion of the search 30 April 2025	Examiner Bertran Nadal, Josep
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