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(54) Title: MEMBRANE ASSEMBLY

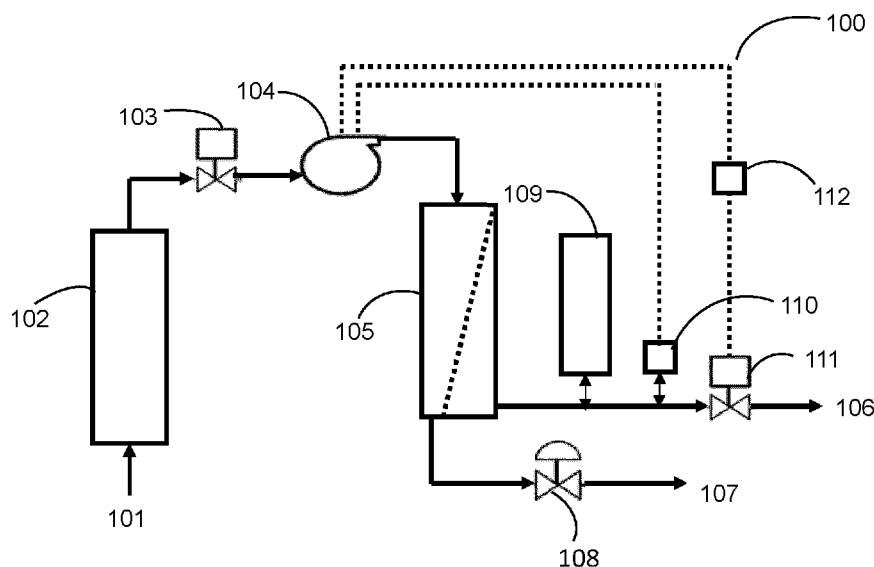


Figure 1/1

(57) Abstract: The present invention relates to a membrane system and a process for cleaning the membrane. The invention also provides a method for enhancing the life of the filtration membrane by the process of cleaning the membrane module. The present inventors investigated ways of improving the cleaning process in a membrane module, particularly the reverse osmosis membrane assembly to avoid the scaling and fouling of the membrane while enhancing the recovery of the purified water and membrane life. It is thus an object of the present invention to provide a membrane assembly which reduces scaling and fouling of the membrane module while enhancing the membrane life. The present inventors have surprisingly found that in a membrane assembly (100) comprising a pressurizable reservoir (109) for cleaning a membrane module (105), the membrane life is significantly improved by initiating a back-flow cleaning when the pressure in the pressurizable reservoir reaches a predetermined pressure value and wherein the predetermined



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pressure value is selected to maintain a difference in pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for 2 minutes.

MEMBRANE ASSEMBLY

Field of the invention

- 5 The present invention relates to a membrane assembly and a process for cleaning the membrane. The invention also provides a method for enhancing the life of the membrane.

10 Background of the invention

Water purifiers based on membrane module systems are the most popular technology for water purification and it removes biological, colloidal, organic and dissolved salts from water.

- 15 When the membrane assembly is continuously operated over a period of time, the membrane module is subject to fouling. The membrane can be fouled by bio-films, organic material or colloidal material deposited on its surface. However, the most significant reason for decline in permeate flow-rate is the formation of scales, which are usually deposits of calcium salts on the membrane surface. The deposition of scale
20 leads to a decline in the flow of permeate water as well as the total flow through the system. Fouling limits the operating flux, decreases water production, increases power consumption and requires periodical membrane cleaning.

- To improve the flow of permeate water through a membrane module and to reduce
25 fouling of the membrane, different techniques have been employed. These include removal of solids from a membrane surface by using a series of chemical cleaning cycles or application of a pressurized liquid and/or gaseous backwash cleaning cycle. Frequent cleaning of a membrane module may result in low effectiveness, high cost and adds to environmental impact related to the disposal of chemicals used in
30 cleaning. It is desired to provide a membrane assembly in which the problems associated with scaling are reduced and which also provides more effective membrane cleaning.

One such attempt at cleaning the membrane module was made in WO 2016/066382 A1 (Unilever) which discloses a water purifier comprising a pump; a membrane module, a first valve to control the water flow into the membrane module; and a permeate line for purified water and a reject line for discarded water; wherein the reject
5 line comprises a valve; and wherein the water purifier comprises a pressurizable chamber and a second valve in sequence downstream the membrane module in the permeate line and wherein said reject line is downstream of said membrane module.

US 2015/246300 A1 (Chancellor Dennis) discloses a filtration system having a flushing
10 sub-system. The flushing sub-system includes a permeate storage chamber configured to store a predetermined volume of permeate and a discharge mechanism which upon actuation interrupts the permeate flow through a permeate outlet and expels at least a portion of the permeate stored in the permeate storage chamber through the filter unit in a reverse direction.

15 US 9 457 298 B2 (Van Opdorp Robertus Martinus) discloses an automatic backwashing system for membrane filter in a water treatment plant without the use of electrical measuring, control technology or an electric drive to produce drinking water in areas where there is no electricity available.

20 The present inventors investigated ways of improving the cleaning process in a membrane module, particularly the reverse osmosis membrane assembly to avoid the scaling and fouling of the membrane while enhancing the recovery of the purified water and enhancing membrane life.

25 However, the present inventors have found that when using pressurized permeate water for membrane cleaning, the membrane is prone to delamination resulting in poor salt rejection or the dislodging of the deposits from the membrane is not effective. Thus, there is still a need for a membrane assembly which provides improved cleaning
30 of the membrane while enhancing the recovery of permeate water and improving the membrane life.

It is thus an object of the present invention to provide a membrane assembly which reduces scaling and fouling of the membrane module while enhancing the membrane life.

- 5 It is another object of the present invention to provide a membrane assembly which provides an effective removal of fouling and scaling throughout the life of the membrane.

- 10 It is yet another object of the invention to provide an improved method for purifying municipal water for drinking purposes employing membrane assembly where cleaning of the membrane is facilitated to improve flux.

- 15 It is a further object of the present invention to provide a membrane assembly which provides a process for cleaning the membrane module by avoiding the use of an additional mechanical fluid pressurizing device such as a pump for backwash cleaning and thus reducing power consumption.

- 20 It is yet another object of the present invention to provide a membrane assembly requiring no membrane change for extended periods.

Summary of the invention

- The present inventors have surprisingly found that in a membrane assembly comprising a pressurizable reservoir for cleaning a membrane module, the membrane life is significantly improved by initiating a back-flow cleaning when the pressure in the pressurizable reservoir reaches a predetermined pressure value and wherein the predetermined pressure value is selected from 40 psig to 80 psig and maintains and maintains a difference in pressure between the permeate line and the concentrate line of the membrane module during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.
- 25
30

According to a first aspect disclosed is a membrane assembly for treating water, the assembly comprising:

- i. a pump adapted to discharge incoming feed water under a pump pressure;
 - ii. a membrane module connected to (a) a feed line in fluid communication with the pump, (b) a permeate line adapted for connection to a dispenser of permeate water and, (c) a concentrate line adapted for connection with a drain of concentrate water;
 - 5 iii. a flow restricting means disposed on the concentrate line for draining concentrate water at a predetermined rate;
 - iv. a pressurizable reservoir in fluid communication with the permeate line and adapted to store permeate water under pressure;
 - 10 v. a valve means downstream the pressurizable reservoir adapted to close the permeate line for building pressure in the pressurizable reservoir to reach a predetermined pressure value;
 - vi. a controlling means operably connected to the pump for switching off the pump when the pressurizable reservoir reaches the predetermined pressure value
 - 15 and triggering the back flow of the pressurized permeate water from the pressurizable reservoir through the membrane module from a permeate side to the concentrate line;
- characterised in that the predetermined pressure value is selected from 40 psig to 80 psig and maintains a difference in pressure between the permeate line and the
- 20 concentrate line during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

According to a second aspect of the present invention disclosed is a process for cleaning the membrane assembly according to the first aspect, said process

25 comprising the steps of:

- i. operating the pump adapted to discharge incoming feed water under a pump pressure to a membrane module through a feed line in fluid communication with the pump;
- ii. allowing the membrane module to produce a pure permeate water stream which
- 30 flows out through a permeate line adapted for connection to a dispenser of permeate water and concentrating the feed stream which flows out through a concentrate line adapted for connection with a drain of concentrate water;

- iii. draining the concentrated water at a predetermined rate through a flow restricting means disposed on the concentrate line;
 - iv. providing a pressurizable reservoir in fluid communication with the permeate line and adapted to store permeate water under pressure;
 - 5 v. closing the valve means downstream the pressurizable reservoir; allowing the pump to continue operation for flowing the permeate water into the pressurizable reservoir to build up the pressure in the reservoir to reach a predetermined pressure value;
 - vi. allowing the controlling means to switch off the pump when the pressure in the
10 pressurizable reservoir reaches the predetermined pressure value;
 - vii. forcing the permeate water in the pressurizable reservoir to back flow from the pressurizable reservoir through the membrane module from a permeate side to the concentrate line;
- characterised in that the predetermined pressure value is selected from 40 psig to 80
15 psig and maintains a difference in pressure between the permeate line and the concentrate line during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

According to a third aspect of the present invention disclosed is a water purification
20 system comprising the membrane assembly of the first aspect.

According to a fourth aspect of the present invention disclosed is the use of a membrane assembly according to the first aspect for enhancing the life of the membrane module by 1.25 times to 50 times.

25

As used herein, the term "permeate" refers to that portion of the incoming feed water which passes through the membrane surface.

As used herein, the term "concentrate" defines that portion of the incoming feed water
30 exiting the membrane module containing retained, non-permeating species through the concentrate line.

Detailed description of the invention

According to the first aspect of the present invention disclosed is a membrane assembly for treating water, the assembly comprising a pump, a membrane module, a flow restricting means, a pressurizable reservoir, a valve means and a controlling
5 means.

Pump

The membrane assembly according to the present invention includes a pump adapted to discharge incoming feed water under a pump pressure. Preferably the pressure
10 under which the incoming feed water is discharged is from 5 psig (0.34 bar) to 1000 psig (68.94 bar) and, still preferably from 50 psig (3.44 bar) to 500 psig (34.47 bar), most preferably from 60 psig (4.13 bar) to 120 psig (8.27 bar).

Although various types of pumps may be employed, the pump is typically a positive
15 displacement pump, preferably a diaphragm pump.

The capacity of the pump will depend upon the size of water purification system involved; for illustration, in a typical domestic installation, a pump with a delivery rate of preferably 0.2 liters per minute to 60 liters per minute at a pressure of at least 50 psig
20 (3.44 bar), more preferably 0.4 liters per minute to 10 liters per minute at a pressure of at least 50 psig (3.44 bar) and more preferably 0.5 litres per minute to 5 litres per minute at a pressure of at least 50 psig (3.44 bar).

The incoming feed water is preferably passed through a pre-filter before entering the
25 pump. The pre-filter employed may include any sediment filter.

Preferably a feed valve is operably connected to the pump for controlling the flow rate of the incoming water flowing into the membrane module.

30 Further the pump is preferably connected to a measuring means for determining the pump current value, wherein preferably the measuring means is a current sensing integrated circuit. The pump current value is an indicator of an increase in the pump pressure value and as described hereinafter the controlling means is programmable to

increase predetermined pressure value in response an increase in the pump pressure value.

Membrane module

- 5 The membrane assembly according to the present invention includes a membrane module connected to (a) a feed line in fluid communication with the pump, (b) a permeate line adapted for connection to a dispenser of permeate water and, (c) a concentrate line adapted for connection with a drain of concentrate water.
- 10 Preferably the membrane module comprises a membrane selected from ultrafiltration membrane, microfiltration membrane, nanofiltration membrane or a reverse osmosis membrane. Preferably the membrane is a reverse osmosis membrane.

The membrane may be of various configurations such as hollow fibre, flat sheet, spiral
15 wound sheet or tubular. Preferably for the purposes of the present invention, the hollow fibre membrane and spiral wound membrane are employed. In a preferred embodiment the membrane module is a cross-flow reverse osmosis membrane, preferably a spirally wound membrane.

- 20 The membrane used in the membrane module may be made from a wide selection of synthetic polymeric materials, particularly those of low water adsorptivity. Such polymers which may be employed include polycarbonates, polyamides, halogenated polymers such as polyvinylidene fluoride, polychloroethers, polyacetate, polyacrylics, polyurethanes, polyimides, polyvinylacetate and polyethers.

25

- Preferably a feed valve is in fluid communication with the membrane module to control the water flow from the pump into the membrane module. It is preferable that the feed valve is operably connected to pump such that the feed valve is open when the pump is powered and closed when the pump is switched off. Preferably the feed valve is a
30 solenoid type valve. It is preferred that the operation of the feed valve is controlled using electronic control systems.

The present invention preferably can be incorporate membrane module with capacities ranging from 5 L/hour to 1000 L/hour permeate production rate.

Flow restricting means

- 5 The membrane assembly according to the present invention includes a flow restricting means disposed on the concentrate line for draining concentrate water at a predetermined rate. Preferably the predetermined rate for draining the reject water from the concentrate line is from 0.1 litres/minute to 40 litres /minute, more preferably from 0.2 litres /minute to 5 litres /minute, most preferably 0.35 litres /minute to 0.6
10 litres/minute.

Preferably the flow restricting means is an on-off valve, solenoid value or throttle type valve, preferably a throttle type valve.

15 Pressurizable reservoir

- The membrane assembly according to the present invention includes a pressurizable reservoir in fluid connection with the permeate line and adapted to store permeate water under pressure. The pressurizable reservoir downstream the membrane module and upstream a valve means is capable of storing the permeate water flowing from the
20 membrane module and maintain it under pressure for back flow operation during the cleaning cycle.

- Preferably the pressurizable reservoir includes a pressure relief valve which is fitted to relieve pressure from the reservoir in the event the pressure within the reservoir
25 exceeds a selected safety level.

- In this document, the terms back flow and backwash are used interchangeably to describe flow of purified permeate water in a reverse direction during the cleaning cycle relative to the flow of water during production cycle through the membrane module
30 from the permeate side to the concentrate line, with the driving pressure arising from the pressurizable reservoir.

Valve means

The membrane assembly according to the present invention includes a valve means downstream the pressurizable reservoir adapted to close the permeate line for building pressure in the pressurizable reservoir to reach a predetermined pressure value.

- 5 In a preferred embodiment the membrane assembly comprises a volume sensor operably connected to the valve means and the output of purified water from the permeate line.

10 In one embodiment of the present invention, the valve means connected to the permeate line downstream the pressure reservoir also serves as the dispenser for permeate water.

15 In a more preferred embodiment of the present invention, two different valve means are provided downstream of the pressurizable reservoir, one valve means is adapted to close the permeate line for building the pressure in the pressurizable reservoir and the other valve means, connected to the permeate line, serves as a dispenser of permeate water.

20 Preferably the valve means is a solenoid type valve. It is preferred that the operation of the valve means may be efficiently controlled using electronic control systems.

Controlling means

25 The membrane assembly according to the present invention includes a controlling means operably connected to the pump for switching off the pump when the pressurizable reservoir reaches the predetermined pressure value and triggering the back flow of the pressurized permeate water from the pressurizable reservoir through the membrane module from a permeate side to the concentrate line.

30 Preferably the controlling means is a pressure responsive means positioned between the membrane module and the valve means for sensing the pressure in the reservoir and controlling the switching-off of the pump when pressure in the pressurizable reservoir reaches a predetermined pressure value. Preferably the pressure responsive means is operably connected to the pressurizable reservoir and the pump. The

pressure responsive means is pre-calibrated and/or is capable of being re-calibrated during operation.

5 Preferably during the life of the membrane assembly, the pressure responsive means is programmable to increase the predetermined pressure value in response to an increase in the operating pump pressure value to maintain the difference in the pressure between the permeate line and the concentrate line during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

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Pressure responsive means is of any known type more preferably a pressure switch, preferably a high-pressure switch.

15 Alternately, in the membrane assembly according to the present invention the controlling means is a timer operably connected to the valve means and the pump for switching-off the pump when a predetermined time corresponding to pressurizable reservoir attaining the predetermined pressure value has elapsed. The predetermined time is measured from the closing of the valve means and for the duration during which the pump is in operation.

20

With the membrane module put to use for treating feed water to produce permeate water with reduced concentration of the dissolved particles, it is observed that over a period of time there is an increase in the pump pressure value required for driving the feed water through the membrane module. An increase in the pump pressure value
25 alters the pressure difference between the permeate line and the concentrate line during the back flow operation after the pump is switched off. In order to provide for any changes in the pump pressure value in a preferred embodiment, the controlling means is programmable to increase the predetermined pressure value in response to an increase in the pump pressure value to maintain the difference in the pressure between
30 the permeate line and the concentrate line during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

Preferably the predetermined pressure value is selected to maintain a difference in pressure between the permeate line and the concentrate line during the back flow operation in a range from 8 psig (0.55 bar) to 18 psig (1.24 bar), preferably from 10 psig (0.69 bar) to 18 psig (1.24 bar), still preferably from 13 psig (0.89 bar) to 18 psig (1.24 bar), further preferably 14 psig (0.97 bar) to 18 psig (1.24 bar), also preferably from 10 psig (0.69 bar) to 15 psig (1.03 bar), for at least 2 minutes. Preferably during the back flow operation, the pressure difference is maintained for a period of at least 2 minutes, still preferably at least 3 minutes, further preferably at least 5 minutes. It is preferred that the pressure difference is maintained for a period of 3 minutes to 5 minutes.

Preferably the controlling means is programmable to increase the predetermined pressure value in response to a predefined volume of permeate water collected corresponding to an increase in the pump pressure value. In yet another preferred embodiment the controlling means is programmable to increase the predetermined pressure value in response to attaining a predefined pump current value corresponding to an increase in the pump pressure value.

Process for cleaning the membrane assembly

In operation, the membrane assembly (100) according to the present invention involves a production cycle initiated by switching on the pump (104) and opening the valve means (111). The pump (104) discharges incoming feed water under a pump pressure through the membrane module (105). The water is filtered through the membrane module (105) and the permeate water flows into the permeate line (106) and the concentrated water flows out through the concentrate line (107).

Typically, with usage the membrane module (105) fouls, requiring cleaning. The cleaning cycle is initiated with the closing of the valve means (111). Upon closing the valve means, the pump (104) is still in operation and the membrane module continues to produce permeate water which flows into the permeate line and thereafter collects in the pressurizable reservoir (109). The pump operating after the closing the valve means (111) allows the permeate water to flow into and build up the pressure in the pressurizable reservoir (109). When the pressure in the pressurizable reservoir (109)

reaches the predetermined pressure value, the controlling means which is preferably a pressure responsive means (110) is triggered and switches off the pump (104). The switching-off of the pump leads to pressure drop on the feed line (101) of the membrane and forces the permeate water in the pressurizable reservoir (109) to back-flow through the membrane module (105) from a permeate side to the concentrate line (107) in a reverse direction. The predetermined pressure value setting in the pressurizable reservoir (109) is selected to maintain the difference in pressure between the permeate line (106) and the concentrate line (107) of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes. Preferably the difference in pressure is maintained for a period from 3 to 5 minutes.

Preferably the predetermined pressure value is selected to maintain the difference in the pressure between the permeate line (106) and the concentrate line (107) during the back flow operation in the range from 8 psig (0.55 bar) to 15 psig (1.03 bar), preferably from 10 psig (0.69 bar) to 18 psig (1.24 bar), still preferably from 13 psig (0.89 bar) to 18 psig (1.24 bar), further preferably 14 psig (0.97 bar) to 18 psig (1.24 bar), also preferably from 10 psig (0.69 bar) to 15 psig (1.03 bar) for at least 2 minutes. Preferably to maintain the difference in pressure between the permeate line and the concentrate line for a duration of 3 minutes to 5 minutes.

In a preferred embodiment, to overcome the effects of any increase in the pump pressure value with continued usage over a period of time the membrane assembly according to the present invention provides that the controlling means is programmable to increase the predetermined pressure value in response to an increase in the pump pressure value to maintain the difference in the pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

According to a second aspect of the present invention disclosed is a process for cleaning the membrane assembly (100) according to the first aspect, said process comprising the steps of:

- i. operating the pump (104) adapted to discharge incoming feed water under a pump pressure to a membrane module (105) through a feed line (101) in fluid communication with the pump (104);
 - ii. allowing the membrane module (105) to produce a pure permeate water which flows out through a permeate line (106) adapted for connection to a dispenser of permeate water and concentrating the feed stream which flows out through a concentrate line (107) adapted for connection with a drain of concentrate water;
 - iii. draining the concentrate water at a predetermined rate through a flow restricting means (108) disposed on the concentrate line (107);
 - iv. providing the pressurizable reservoir (109) in fluid communication with the permeate line (106) and adapted to store permeate water under pressure;
 - v. closing the valve means (111) downstream the pressurizable reservoir (109); allowing the pump (104) to continue operation for flowing the permeate water into the pressurizable reservoir (109) and increasing the pressure in reservoir (109) to reach a predetermined pressure value;
 - vi. allowing the controlling means to switch off the pump (104) when the pressure in the pressurizable reservoir (109) reaches the predetermined pressure value;
 - vii. forcing the permeate water in the pressurizable reservoir (109) to back flow through the membrane module (105) from a permeate side to the concentrate line (107);
- characterised in that the predetermined pressure value is selected from 40 psig to 80 psig and maintains a difference in pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

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Preferably the step of forcing the permeate water stored in the pressurizable reservoir (109) to back flow through the membrane module (105) in a reverse direction from a permeate side to the concentrate line continues until the pressure in the pressurizable reservoir dissipates to less than 5 psig (0.34 bar) and more preferably is in the range from 0 psig (0 bar) to 1 psig (0.07 bar).

30

The frequency of the cleaning process is preferably determined by the volume of permeate water collected from the permeate line or by the pump running time taken for

obtaining a predetermined volume of permeate water. It is preferable to use the output volume of permeate water from the permeate line as the parameter for determining the frequency at which to close the valve means to start the process of cleaning the membrane module.

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In a preferred embodiment the membrane assembly includes a volume sensor on the permeate line for measuring the volume of permeate water and closing the valve means when the predetermined volume of the permeate water is passed through the permeate line. Preferably the valve means closes after the volume sensor senses
10 predetermined output volume of permeate water in the range from 2 litres to 1000 litres. In a preferred embodiment when the closing of the valve means is determined by the pump running time taken for obtaining a predetermined volume of permeate water, the valve means is closed after a predetermined time-period ranging from 10 minutes to 20 days of operation of the membrane assembly.

15

After the closure of the valve means, the pump is allowed to continue operation until a predetermined pressure value is built up in the pressurizable reservoir or a predetermined volume of water corresponding to the predetermined pressure value is collected in the pressurizable reservoir or a predetermined time required for the
20 pressure to reach the predetermined pressure value has elapsed. The membrane assembly preferably includes a timer which is set at the predetermined time to achieve the desired predetermined pressure value and the timer is operably connected to the valve means and the pump for switching off the pump when the predetermined time has elapsed.

25

After closing the valve means, the pump is allowed to continue operation until the pressure switch senses a predetermined pressure value in the pressurizable reservoir in the range from 40 psig (2.76 bar) to 80 psig (5.52 bar). More preferably the pump is allowed to continue operation until the pressure in the pressurizable reservoir reaches
30 a predetermined pressure value from 45 psig (3.1 bar) to 60 psig (4.14 bar) and most preferably the pump is allowed to continue operation until the pressure in the pressurizable reservoir reaches a predetermined pressure value 45 psig (3.1 bar) to 55 psig (3.79 bar) and further most preferably from 45 psig (3.1 bar) to 50 psig (3.44 bar),

and where the predetermined pressure value is selected to maintain a difference in pressure between the permeate line and the concentrate line of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes, more preferably 3 to 5 minutes.

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In another preferred embodiment, the pump is allowed to continue operation until the timer senses a predetermined time period of 1 second to 3600 seconds more preferably from 5 seconds to 600 seconds. The predetermined time is measured from the closing of the valve means and for the duration during which the pump is in

10

In another preferred embodiment, the pump is allowed to continue operation until 0.01 litres to 5 litres more preferably 0.02 litres to 0.5 litres of water is collected in the pressurizable reservoir. This water is utilized to clean the membrane module.

15

According to a second aspect of the present invention disclosed is a water purification system having the membrane assembly of the present invention and as disclosed in the first aspect.

20 According to a fourth aspect of the present invention disclosed is the use of a membrane assembly according to the first aspect for enhancing the life of the membrane module by 1.25 to 50 times.

Brief description of figures

25 Figure 1 is a schematic depiction of the membrane assembly of the present invention.

Detailed description of figures

Figure 1 shows the membrane assembly (100) of the present invention. Under the
30 operation of a powered pump (104), the feed water in the feed line (101) enters a pre-filter (102) to remove any sediment particles present in the incoming feed water. Thereafter the feed water flow through the feed valve (103) and is discharged through the pump (104) under a pump pressure into the membrane module (105). The water is

filtered through the membrane module (105) and the permeate water flows into the permeate line (106) and the concentrated water flows into the concentrate line (107). The concentrate water flows out of the membrane module (105) and drains out at a predetermined flow rate regulated by a flow restricting means (108) disposed on the concentrate line (107). The permeate water flows out of the membrane module (105) and is made to pass via the open valve means (111). When the valve means (111) closes, the permeate water accumulates and is stored under pressure in a pressurizable reservoir (109) in fluid communication with the permeate line (106). A pressure switch (110) operably connected to the pump (104) and the pressurizable reservoir (109) provides for switching off the pump when the pressurizable reservoir (109) reaches the predetermined pressure value. A timer (112) operably connected to the valve means (111) and the pump (104) is also provided.

15 Examples

Evaluation of the membrane assembly according to the Invention (Ex 1)

The membrane assembly according to the present invention (Ex 1) as depicted in Figure 1 was used for the study. The incoming feed water from the feed line (101) was made to enter the pre-filter (102) and then through a feed valve (103) the feed water entered a 100 GPD diaphragm pump (104). The pump (104) discharged the feed water under a pressure into a 100 GPD membrane module (105). A sediment filter (PP melt blown non-woven filter) (102) was used as the pre-filter (102). The membrane assembly according to the invention (100) was operated at a pressure of 80 psig (5.52 bar) by regulating the flow of concentrate water at a predetermined value of 600 mL/minute through a flow restricting means (capillary valve) (108) disposed on the concentrate line (107). Predetermined pressure value was set at 45 psig (3.10 bar) by calibrating the high- pressure switch (109).

The pressure in the permeate line (106) and concentrate line (107) were measured with standard pressure gauges (not shown in figure 1). The total dissolved salt concentration (TDS) of the feed water and the TDS and flow rate of the permeate water in the permeate line (106) and the concentrate water in the concentrate line (107) were measured at regular intervals of every 30 liters (approximately) of permeate water

(purified water) collected. It was observed that the TDS of feed water varied from 1000 ppm to 1100 ppm.

5 The permeate line (106) was further connected to a valve means (normally closed solenoid valve 111). The set-up was operated in such a way that initially both feed valve (103) and the valve means (111) were open and the whole set-up was operated as a conventional membrane-based water purifier producing permeate water. After collecting (manually measured) approximately 10 liters of permeate water from the permeate line (106), the valve means (111) was closed.

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Upon closing the valve means (111), the pump (104) was continuously operated and the permeate water started to accumulate in the pressurizable reservoir (109) and pressure started to build up, when the pressure in the pressurizable reservoir (109) reached the predetermined pressure value of 45 psig (3.10 bar), the high-pressure
15 switch (110) was triggered and this in turn controlled the pump (104) which was switched off. After the pump was switched off, the permeate water at higher pressure in the pressurizable reservoir (109) started to flow in the reverse direction (105) from a permeate side through the membrane module to the concentrate line (108) thereby resulting in cleaning of the membrane from within. It took around 10 minutes for the
20 permeate water collected in the pressurizable reservoir (109) to flow through the membrane module and drain out through the concentrate line (108) causing the dissipation of the pressure in the pressurizable reservoir to less than 5psig (0.34 bar).

During the back flow operation, the pressure in the permeate line (106) and the
25 concentrate line (107) was measured at specific time intervals using standard pressure gauge and the data was recorded and is provided in Table 1 below.

Table 1

Time (Seconds)	Permeate line pressure (psig)	Concentrate line pressure (psig)	Difference* (psig)
	Predetermined pressure value = 45psig		
0	45	80	-35
6	35	30	5
13	30	19	11
20	25	12	13
41	18	5	13
60	15	2	13
70	15	2	13
92	13	0	13
105	13	0	13
118	12	0	12
135	11	0	11
155	10	0	10
175	10	0	10
190	8	0	8
225	7	0	7
286	6	0	6
385	5	0	5

* difference in pressure between the permeate line and the concentrate line during the back flow operation

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The data in table 1 clearly shows that a difference in pressure between the permeate line and the concentrate line was maintained between 10 psig (0.69 bar) to 15 psig (1.03 bar) for 2.7 minutes (162 seconds) during the back-flow operation. Further the data in table 1 shows that the difference in pressure between the permeate line and the concentrate line was less than 18 psig (1.24 bar) (maximum of 13 psig, 0.89 bar) as required by the present invention.

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Control membrane assembly (Ex A)

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The performance of membrane assembly of the present invention was further evaluated using a control membrane assembly. The configuration of the control

membrane assembly (Ex A) was similar to the membrane assembly according to the present invention (figure 1) except that the control membrane assembly (Ex A) did not include a pressurizable reservoir (109), a high-pressure switch (110), valve means (111) and timer (112). The control membrane assembly (Ex A) did not include any
 5 cleaning system for period cleaning of the membrane and was devoid of any other scale prevention technology.

A comparative membrane assembly (Ex B) similar to the membrane assembly of the present invention (Ex 1) was also operated in a similar fashion as in Example 1
 10 described above except that, in this membrane assembly (Ex B) the predetermined pressure value was set at 25 psig (1.72 bar) by calibrating the high- pressure switch (109).

The flow rate performance at regular intervals of time for the control membrane
 15 assembly (Ex A) and the membrane assembly (Ex 1) according to the present invention and the comparative membrane assembly (Ex B) were recorded till the flow rate dropped to 100mL/minute. The data was recorded and is provided in Table 2.

Table 2- Evaluation of the membrane life of the membrane assembly

#Permeate water (litres)	Flow rate of the permeate water through the membrane assembly (mL/minute)		
	Ex A	Ex 1	Ex B
0	420	420	420
1000	350	335	330
2000	310	300	315
3000	210	275	300
4000	200	240	235
5000	115	205	205
6000	100	180	200
7000	-	160	150
8000	-	160	130
9000	-	155	110
10000	-	150	100

11000	-	150	-
12000	-	130	-
13000	-	110	-

*Permeate- the total volume of permeate obtained from the membrane assembly

The data in table 2 show that the flow rate of permeate water through the control membrane assembly (Ex A) dropped steadily from 420 mL/minute, when the membrane is new, to 100 mL/minute by the time 6000 liters of permeate water was obtained from the assembly. Further in the comparative membrane assembly running at a lower predetermined pressure value of 25 psi the flow rate of the permeate water dropped to 100 mL/minute by the time 10,000 litres of permeate water was obtained from the assembly. As compared to this, the membrane assembly according to the present invention (Ex 1) in which the membrane was subjected to cleaning using back flow as described in the present invention, the flow rate through the membrane assembly (Ex 1) dropped steadily from 420 mL/minute, when the membrane is new, to 100 mL/minute by the time 13000 liters of permeate water was obtained from the assembly.

Thus, the data in Table 2 demonstrates that the membrane assembly according to the present invention (Ex 1) in which the predetermined pressure value is selected from 40 psig to 80 psig and maintains a pressure difference in the permeate line and the concentrate line during the back flow operation of less than 18 psig (1.24 bar) for 2.7 minutes showed a significant improvement in the membrane life over the control membrane assembly and the comparative membrane assembly without affecting the membrane properties. The membrane life in the assembly according to the present invention was enhanced by 2.1 times as compared to the control membrane assembly and by 1.3 times as compared to Ex B.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reading and understanding the above description.

Claims

- 1 A membrane assembly (100) for treating water, the assembly (100) comprising:
 - i. a pump (104) adapted to discharge incoming feed water under a pump pressure;
 - ii. a membrane module (105) connected to (a) a feed line (101) in fluid communication with the pump (104), (b) a permeate line (106) adapted for connection to a dispenser of permeate water and, (c) a concentrate line (107) adapted for connection with a drain of concentrate water;
 - iii. a flow restricting means (108) disposed on the concentrate line (107) for draining concentrate water at a predetermined rate;
 - iv. a pressurizable reservoir (109) in fluid communication with the permeate line (106) and adapted to store permeate water under pressure;
 - v. a valve means (111) downstream the pressurizable reservoir (109) adapted to close the permeate line (106) for building pressure in the pressurizable reservoir (109) to reach a predetermined pressure value;
 - vi. a controlling means operably connected to the pump (104) for switching off the pump when the pressurizable reservoir (109) reaches the predetermined pressure value and triggering the back flow of the pressurized permeate water from the pressurizable reservoir (109) through the membrane module (105) from a permeate side to the concentrate line (107);characterised in that the predetermined pressure value is selected from 40 psig (2.76 bar) to 80 psig (5.52 bar) and maintains a difference in pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar) for at least 2 minutes, preferably less than 15 psig (1.03 bar) for at least 2 minutes.
- 2 A membrane assembly (100) according to claim 1 wherein the predetermined pressure value is selected to maintain a difference in pressure between the permeate line (106) and the concentrate line (107) during the back flow operation in a range from 8 psig (0.55 bar) to 18 psig (1.24 bar), preferably from 10 psig (0.69 bar) to 15 psig (1.03 bar).

- 3 A membrane assembly (100) according to claim 1 wherein the controlling means is a pressure responsive means (110) positioned between the membrane module (105) and the valve means (111) for sensing the pressure in the reservoir (109) and controlling the switching-off of the pump (104) when pressure in the pressurizable reservoir (109) reaches the predetermined pressure value.
- 4 A membrane assembly (100) according to claim 3 wherein the pressure responsive means (110) is a high-pressure switch.
- 5 A membrane assembly (100) according to claim 1 wherein the controlling means is a timer operably connected to the valve means (111) and the pump (104) for switching off the pump (104) when a predetermined time corresponding to pressurizable reservoir (109) attaining the predetermined pressure value has elapsed.
- 6 A membrane assembly (100) according to any one of the preceding claims wherein the controlling means is programmable to increase the predetermined pressure value in response to an increase in the pump pressure value to maintain the difference in the pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.
- 7 A membrane assembly (100) according to claim 6 wherein the controlling means is programmable to increase the predetermined pressure value in response to attaining a predefined pump current value corresponding to an increase in the pump pressure value.
- 8 A membrane assembly (100) according to any one of the preceding claims comprises a feed valve (103) operably connected to the pump (104) for controlling the flow rate of the incoming feed water into the membrane module (105).

- 9 A membrane assembly (100) according to any one of the preceding claims wherein the membrane module (105) comprises a membrane selected from ultrafiltration membrane, microfiltration membrane, nanofiltration membrane or a reverse osmosis membrane.
- 10 A membrane assembly (100) according to claim 9 wherein the membrane is a spiral wound membrane.
- 11 A process for cleaning the membrane assembly (100) according to claim 1, said process comprising the steps of:
- i. operating the pump (104) adapted to discharge incoming feed water under a pump pressure to a membrane module (105) through a feed line (101) in fluid communication with the pump (104);
 - ii. allowing the membrane module (105) to produce a pure permeate water stream which flows out through a permeate line (106) adapted for connection to a dispenser of permeate water and concentrating the feed stream which flows out through a concentrate line (107) adapted for connection with a drain of concentrate water;
 - iii. draining the concentrated water at a predetermined rate through a flow restricting means disposed on the concentrate line;
 - iv. providing a pressurizable reservoir (109) in fluid communication with the permeate line (106) and adapted to store permeate water under pressure;
 - v. closing the valve means (111) downstream the pressurizable reservoir (109); allowing the pump (104) to continue operation for flowing the permeate water into the pressurizable reservoir (109) to build up the pressure in the reservoir (109) to reach a predetermined pressure value;
 - vi. allowing the controlling means to switch off the pump (104) when the pressure in the pressurizable reservoir (109) reaches the predetermined pressure value;
 - vii. forcing the permeate water in the pressurizable reservoir (109) to back flow from the pressurizable reservoir (109) through the membrane module (105) from a permeate side to the concentrate line (107);

characterised in that the predetermined pressure value is selected from 40 psig (2.76 bar) to 80 psig (5.52 bar) and maintains a difference in pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.

- 12 A process according to claim 11 wherein the controlling means is programmable to increase the predetermined pressure value in response to an increase in the pump pressure value to maintain the difference in the pressure between the permeate line (106) and the concentrate line (107) during the back flow operation of less than 18 psig (1.24 bar), preferably less than 15 psig (1.03 bar) for at least 2 minutes.
- 13 A water purification system comprising the membrane assembly (100) according to any one of the preceding claims 1 to 10.
- 14 Use of a membrane assembly (100) according to claim 1 to 10 or the process according to claim 12 for enhancing the life of the membrane module (105) by 1.25 times to 50 times.

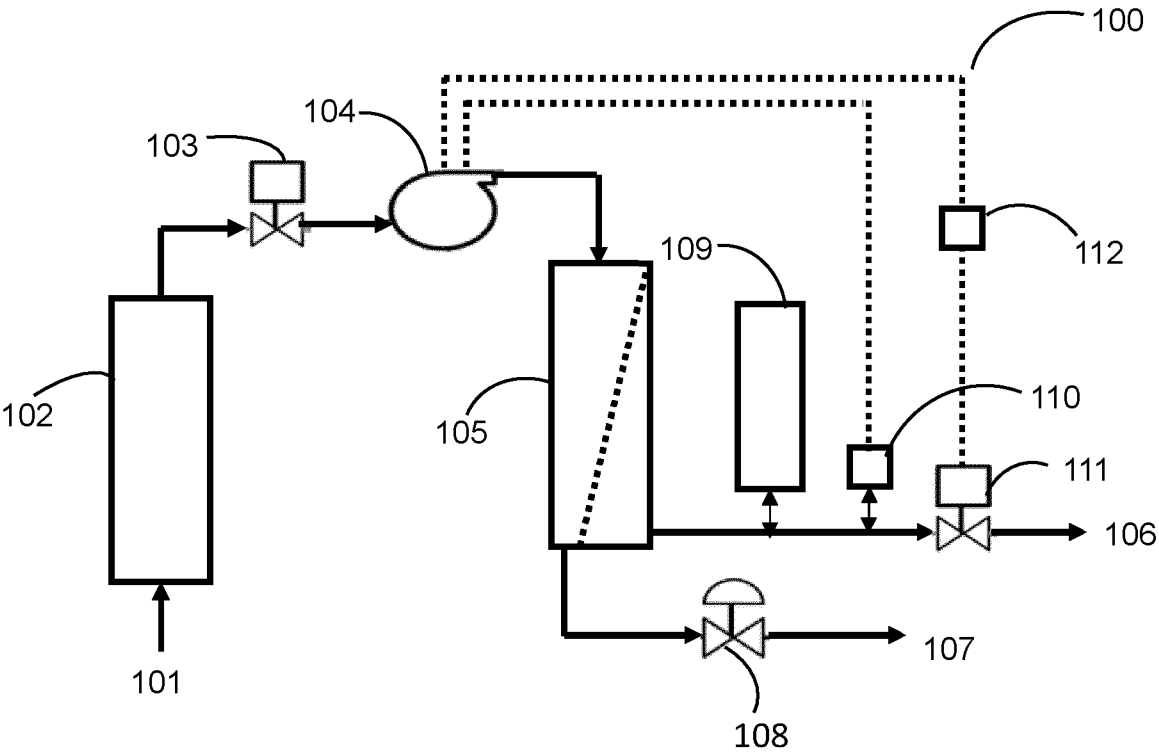


Figure 1/1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052691

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D65/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/246300 A1 (CHANCELLOR DENNIS [US]) 3 September 2015 (2015-09-03) claim 1 page 12, line 19 page 9, line 20 - line 24 -----	1,13
A	US 9 457 298 B2 (VAN OPDORP ROBERTUS MARTINUS [NL]) 4 October 2016 (2016-10-04) claim 1 -----	1,13
Y	WO 2016/066382 A1 (UNILEVER NV [NL]; UNILEVER PLC [GB]; CONOPCO INC DBA UNILEVER [US]) 6 May 2016 (2016-05-06) cited in the application figure 1 page 12, line 19 claim 1 page 9, line 20 - line 24 ----- -/--	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 March 2020

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052691

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 202 793 A1 (TRISEP CORP [US]) 8 May 2002 (2002-05-08) paragraph [0043] -----	1-14
Y	US 2002/100715 A1 (BOSKO ROBERT S [US]) 1 August 2002 (2002-08-01) paragraph [0024] -----	1-14
A	FR 2 979 628 A1 (DUFLOS MICHEL [FR]) 8 March 2013 (2013-03-08) figure 1 claim 1 -----	1,13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/052691

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015246300	A1	03-09-2015	NONE
US 9457298	B2	04-10-2016	BR 112014000254 A2 CN 103732541 A EP 2729417 A2 NL 1038928 C2 US 2014190877 A1 WO 2013006036 A2 ZA 201403167 B
			14-02-2017 16-04-2014 14-05-2014 08-01-2013 10-07-2014 10-01-2013 25-11-2015
WO 2016066382	A1	06-05-2016	NONE
EP 1202793	A1	08-05-2002	AT 411845 T AU 4701099 A CA 2377202 A1 EP 1202793 A1 ES 2317697 T3 WO 0078436 A1
			15-11-2008 09-01-2001 28-12-2000 08-05-2002 16-04-2009 28-12-2000
US 2002100715	A1	01-08-2002	AR 032255 A1 AU 2002240170 B2 BR 0206764 A CA 2435703 A1 CN 1489488 A EG 23103 A EP 1355729 A1 IL 156986 A JP 3927909 B2 JP 2004524141 A KR 20030083702 A MX PA03006770 A MY 126248 A RU 2003124080 A TW I264324 B US 2002100715 A1 WO 02060567 A1
			29-10-2003 29-09-2005 25-02-2004 08-08-2002 14-04-2004 28-04-2004 29-10-2003 10-04-2006 13-06-2007 12-08-2004 30-10-2003 15-10-2004 29-09-2006 10-01-2005 21-10-2006 01-08-2002 08-08-2002
FR 2979628	A1	08-03-2013	NONE