

DESCRIPTION

COMPLEX DESALINATION SYSTEM

Technical Field

[0001]

The present invention relates to a complex desalination system provided with a first water treatment system that filters a first raw water having a high salinity concentration such as seawater, brackish water, brine water, etc., using a reverse osmosis membrane device, and a second water treatment system that filters a second raw water having a salinity concentration lower than that of the first raw water, using a reverse osmosis membrane device, wherein the invention particularly relates to a technology that uses a hydraulic pressure energy of a non-permeate water discharged from the reverse osmosis membrane device of the second water treatment system.

Background Art

[0002]

Patent Document 1 discloses a technology wherein, in a seawater desalination device for desalinating a seawater by filtering using a reverse osmosis membrane device, a wastewater containing an organic matter, for example represented by sewage, (hereinafter, referred to as 'organic wastewater'), which would otherwise usually be processed by a biological treatment and discharged into an ocean or a river, is mixed with a seawater taken in by the seawater desalination device; the salinity concentration of a water to be treated (in other words, water that is to be processed by treatment) in the seawater desalination device is decreased (diluted) from

the salinity concentration of the seawater itself; and the water to be treated whose salinity concentration having been diluted is pressure transferred to the reverse osmosis membrane device of the seawater desalination device so that a driving force required for a pressure transfer pump (corresponding to 'a high-pressure pump' in the present description) is decreased.

[0003]

Further, Patent Document 2 discloses a technology wherein, in a seawater desalination device using a reverse osmosis membrane device, a pressure of a non-permeate water in the reverse osmosis membrane device is collected by a turbo charger and is used for pressurizing a water to be treated in the reverse osmosis membrane device.

Background Art Documents

Patent Documents

[0004]

Patent Document 1: Japanese Patent No. 4481345

Patent Document 2: Japanese Patent Application Laid-open No.
2001-149932 A

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

[0005]

However, in the technology disclosed by Patent Document 1, the pressure in case of using a reverse osmosis membrane device in a water treatment process of an organic wastewater is lower than a pressure in case of using the reverse osmosis membrane device in the water treatment process of the seawater desalination device. Further, as it is no more than that a non-permeate water discharged from the reverse osmosis membrane

device in the water treatment process of the organic wastewater is mixed with a seawater that is directly taken in so that the salinity concentration of the non-permeate water is decreased to be lower than that of the seawater, the energy of the non-permeate water from the reverse osmosis membrane device in the water treatment process of the organic wastewater is at a comparatively low pressure. Consequently, the energy is not used at all to be wasted.

[0006]

An object of the present invention is to provide a complex desalination system capable of effectively utilizing the energy of a non-permeate water of a reverse osmosis membrane device from the complex desalination system, thereby solving the above-described problem.

Means for Solving the Problem

[0007]

In order to solve the above-described problem, a complex desalination system in a first aspect of the invention includes: a first water treatment system for filtering a first raw water having a high salinity concentration by use of a first reverse osmosis membrane device; and a second water treatment system for filtering a second raw water having a salinity concentration lower than the salinity concentration of the first raw water by use of a second reverse osmosis membrane device, wherein the first water treatment system includes: a preliminary filtration device for filtering a water to be treated including the first raw water taken in, in a stage preliminary to the first reverse osmosis membrane device; and a first pump for pressurizing the water to be treated to be supplied to the preliminary filtration device, and wherein the first pump is driven under a hydraulic pressure by a non-permeate water discharged from the second reverse

osmosis membrane device of the second water treatment system, and the non-permeate water having driven the first pump is mixed with the first raw water to produce the water to be treated.

[0008]

As the salinity concentration of the water to be treated of the second water treatment system is lower than the salinity concentration of the water to be treated of the first water treatment system, the hydraulic pressure of the non-permeate water of the second reverse osmosis membrane device is of course significantly lower than the hydraulic pressure of a non-permeate water of the first reverse osmosis membrane device. However, the required degree of raising a pressure by the first pump for pressurizing and supplying the water to be treated including the first raw water to the preliminary filtration device is lower than a required pressure to be applied to the water to be treated to be supplied to the first reverse osmosis membrane device. Accordingly, the first pump is driven under the hydraulic pressure by the non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system. This driving effectively utilizes the hydraulic pressure of the non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system.

Further, the non-permeate water having driven the first pump is mixed with the first raw water of the first water treatment system to produce a water to be treated having a salinity concentration which is diluted from that of the first raw water, having been taken in, of the first water treatment system. This water to be treated reduces the required degree of raising a pressure by a pump which pressurizes the water to be treated to be supplied to the first reverse osmosis membrane device.

[0009]

A complex desalination system in a second aspect of the invention includes: a first water treatment system for filtering a first raw water having a high salinity concentration by use of a first reverse osmosis membrane device; and a second water treatment system for filtering a second raw water having a salinity concentration lower than the salinity concentration of the first raw water by use of a second reverse osmosis membrane device, wherein the first water treatment system includes: a third pump for taking in the first raw water; and a first raw water tank storing the first raw water taken in, and wherein the third pump is driven under a hydraulic pressure by a non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system, and the non-permeate water having driven the third pump is supplied to the first raw water tank.

[0010]

As the salinity concentration of the water to be treated of the second water treatment system is lower than the salinity concentration of the water to be treated of the first water treatment system, the hydraulic pressure of the non-permeate water of the second reverse osmosis membrane device is of course significantly lower than the hydraulic pressure of the non-permeate water of the first reverse osmosis membrane device. However, the required degree of raising a pressure by the third pump for supplying the first raw water to the first raw water tank is lower than a required pressure to be applied to the water to be treated to be supplied to the first reverse osmosis membrane device. Accordingly, the third pump is driven under the hydraulic pressure by the non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system. This driving effectively utilizes the hydraulic pressure of the non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system.

Further, the non-permeate water having driven the third pump is supplied to the first raw water tank of the first water system, and the salinity concentration of the first raw water, having been taken in, of the first water treatment system is diluted. This dilution reduces the required degree of raising a pressure by the pump which pressurizes the water to be treated to be supplied to the first reverse osmosis membrane device.

Advantage of the Invention

[0011]

According to the present invention, there is provided a complex desalination system which effectively utilizes the energy of a non-permeate water of a reverse osmosis membrane device of the complex desalination system.

Brief Description of the Drawings

[0012]

FIG. 1 is a schematic block diagram of a complex desalination system in a basic embodiment;

FIG. 2 is a schematic block diagram of a complex desalination system according to a first embodiment;

FIG. 3 is a schematic block diagram of a complex desalination system according to a second embodiment; and

FIG. 4 is a schematic block diagram of a complex desalination system according to a third and fourth embodiments.

Embodiments for Carrying Out the Invention

[0013]

Complex desalination systems according to embodiments of the present invention will be described below in detail, referring to the drawings.
[0014]

<< Complex Desalination System in Basic Embodiment >>

First, referring to FIG. 1, a complex desalination system 100 in a basic embodiment of the present invention will be described. FIG. 1 is a schematic block diagram of the complex desalination system in a basic embodiment.

The complex desalination system 100 is assumed to be installed in a seaside area, in the vicinity of a brackish lake, in the vicinity of a brackish water area, or the like.

The complex desalination system 100 includes a wastewater treatment system (second water treatment system) 1 for wastewater treatment to make a wastewater (second raw water) A (hereinafter referred to merely as 'wastewater A') having a lower salinity concentration such as industrial wastewater or urban wastewater compared with seawater, brackish water, brine water, and the like, into a reuse of wastewater (hereinafter referred to as 'permeate water B' or 'product water B') such as industrial water other than drinking water; a seawater desalination treatment system (first water treatment system) 3 for water purification treatment to make a water having comparatively high salinity concentration (first raw water) D such as seawater, brackish water, brine water, and the like into a reuse of wastewater (hereinafter referred to as 'permeate water E' or 'product water E') such as industrial water other than drinking water; and a control device 6 for operational control of a pump, a valve, etc. included in the wastewater treatment system 1 and the seawater desalination treatment system 3.

In the following, 'water D having a comparatively high salinity concentration such as seawater, brackish water, brine water, and the like' will be representatively referred to as 'seawater D', and as described above, 'seawater desalination treatment system 3' represents the meaning of description represented by 'seawater D'.

[0015]

(Configuration of Wastewater Treatment System 1)

First, the schematic configuration of the wastewater treatment system 1 will be described, referring to FIG. 1. The wastewater A contains an organic matter and the like, and is introduced from a wastewater intake pipe 51 to a water treatment device (herein after referred to as 'MBR water treatment device 11' and is represented merely by 'MBR' in FIG. 1) using, for example, membrane bioreactor (MBR), and is then processed by a primary treatment. A water to be treated having been processed by the primary treatment by the MBR water treatment device 11 is introduced from the MBR water treatment device 11 by a transfer pump 12 through a pipe 52 temporarily to a treated water tank 13 serving as a buffer of the flow of the water to be treated, and is thus stored. Further, the water to be treated stored in the treated water tank 13 is sucked through a pipe 53 by a supply pump 14 to be supplied to a high-pressure pump 15, and is pressurized by the high-pressure pump 15 to be supplied to the supply port 16a, for the water to be treated, of a low-pressure reverse osmosis membrane device (second reverse osmosis membrane device) 16.

[0016]

The low-pressure reverse osmosis membrane device 16 is configured by disposing plural membrane module units in parallel, for example as described in FIGS. 3 and 4 of Japanese Patent Application Laid-open No. 2001-149932.

The water to be treated supplied from the supply port 16a under a pressure is separated into a permeate water B, which has permeated reverse osmosis membranes and has been purified in the low-pressure reverse osmosis membrane device 16, and a non-permeate water C, which has not permeated the reverse osmosis membranes and is the water to be treated. The permeate water B is supplied as a product water B from a permeate port 16b through a pipe 54, for an external purpose corresponding to the water quality level.

[0017]

The non-permeate water C is supplied from the discharge port 16c of the low-pressure reverse osmosis membrane device 16 through a pipe 56 to a later-described intake tank (first raw water tank) 32, wherein the flow rate is regulated by a back-pressure valve 18 provided midway in the pipe 56. The concentration of TDS (Total Dissolved Solids) of the concentrated non-permeate water C in the wastewater treatment system 1 is approximately 1,200 mg/liter, which is extremely low compared with the concentration of TDS of the seawater D, which is approximately 30,000 mg/liter. Accordingly, the above-described low-pressure reverse osmosis membrane device 16 is operated at a pressure of 0.8 to 1.5 MPa. Incidentally, this operational pressure is set to have a range for increasing the operational pressure to obtain a predetermined flow rate of the permeate water B, accompanying an increase in the dirt of reverse osmosis membranes of the low-pressure reverse osmosis membrane device 16.

Accordingly, the pressure of the non-permeate water C is approximately 0.8 to 1.5 MPa. This pressure is released by the above-described back-pressure valve 18.

An ultrafiltration device may be used instead of the MBR water treatment device 11 of the wastewater treatment system 1.

Incidentally, an arrangement may be made such as to provide a function to recover the pressure of the non-permeate water C as energy in the stage when the pipe 56 introduces the non-permeate water C in the low-pressure reverse osmosis membrane device 16 into the intake tank 32. The details of this arrangement will be described in first to fourth embodiments.

[0018]

(Seawater Desalination Treatment System 3)

In the following, the schematic configuration of the seawater desalination treatment system 3 will be described, referring to FIG. 1. A seawater D is sucked by an intake pump 31 from an intake pipe 81 and supplied into the intake tank 32 by an intake pipe 82 to be stored. As described above, as the non-permeate water C is supplied from the wastewater treatment system 1 by the pipe 56 to the intake tank 32, the seawater D and the non-permeate water C are mixed in the intake tank 32 to become a water to be treated having a lower salinity concentration than that of seawater. In other words, the value of TDS also becomes lower than the value of TDS of the seawater D.

The water to be treated stored in the intake tank 32 is supplied to a pre-treatment filtration device (preliminary filtration device) 34 through a pipe 83 under a predetermined pressure applied by a filtration pump 33.

As the pre-treatment filtration device 34, any one of a UF device using an ultrafiltration membrane (UF membrane), an MF device using a micro filtration membrane (MF membrane), and a sand filtration device may be used. Incidentally, in FIG. 1, 'UF', which refers to an UF device, is described to represent the pre-treatment filtration device 34.

Taking an example of an UF device as the pre-treatment filtration device 34, the UF device is generally driven at 50 to 150 kPa.

[0019]

The water to be treated filtered by the pre-treatment filtration device 34 is transferred through a pipe 84 to a treated water tank 35 to be temporarily stored wherein the treated water tank 35 serves as a buffer of the flow of the water to be treated. The water to be treated stored in the treated water tank 35 is sucked by a supply pump 36 to be supplied to a high-pressure pump 37 through a pipe 85; then is increased in pressure by the high-pressure pump 37, to 3.5 to 6 MPa for example; and is supplied to a treatment water supply port 38a of a seawater reverse osmosis membrane device (first reverse osmosis membrane device) 38. The seawater reverse osmosis membrane device 38 is configured by disposing plural membrane module units in parallel, for example as described in FIGS. 3 and 4 of Japanese Patent Application Laid-open No. 2001-149932. The seawater reverse osmosis membrane device 38 is operated at a higher pressure than the low-pressure reverse osmosis membrane device 16, and the material of the reverse osmosis membranes of the seawater reverse osmosis membrane device 38 has a performance that is durable against a higher pressure.

Incidentally, when the value of TDS or the dirt of the water to be treated supplied to the reverse osmosis membranes of the low-pressure reverse osmosis membrane device 38 increases, this operational pressure is increased to obtain a predetermined flow rate of the permeate water E.

[0020]

The water to be treated supplied from the supply port 38a under a pressure is separated into a permeate water E, which has permeated reverse osmosis membranes and has been purified in the seawater reverse osmosis membrane device 38, and a non-permeate water G, which has not permeated the reverse osmosis membranes and is the water to be treated. The permeate water E is supplied as a product water E from a permeate port 38b

through a pipe 87, for an external purpose corresponding to the water quality level.

[0021]

The non-permeate water G having an operational pressure of the above-described seawater reverse osmosis membrane device 38 is supplied from a discharge outlet 38c through a pipe 89 to a high-pressure supply port 39d of a later-described pressurizing side end portion 39b of an energy recovery device 39; directly exchanges pressure with a water to be treated supplied from the supply pump 36; and is thereafter discharged from a discharge port 39e of the pressurizing side end portion 39b wherein the flow rate is regulated by a back-pressure valve 40 provided midway in a pipe 90.

This non-permeate water G is salinity concentrated seawater, brackish water, or brine water.

The energy recovery device 39 is a direct pressure exchange type in the present embodiment, and is a device, of a known art, configured mainly by a rotor section 39a rotationally driven at a predetermined rotational speed by a motor, not shown, the pressurizing side end portion 39b, and a pressurized side end portion 39c.

[0022]

A pipe 91 is branched from the pipe 85 at the branch point P1 of the pipe 85 between the supply pump 36 and the high-pressure pump 37, and a part of the low-pressure water to be treated supplied by the supply pump 36 is supplied to the supply port 39g at the pressurized side end portion 39c of the energy recovery device 39. Then, the water to be treated supplied to the supply port 39g is pressurized by direct exchange of pressure with the non-permeate water G from the seawater reverse osmosis membrane device 38, and is thereafter further supplied from the discharge port 39f of the pressurized side end portion 39c to a booster pump 41 provided on the

midway of a pipe 92. The booster pump 41 raises the pressure of the water to be treated pressurized by the energy recovery device 39 up to the same pressure as the high-pressure pump 37. The water to be treated supplied from the high-pressure pump 37 and the water to be treated supplied from the pipe 92 are joined together at the junction point P2 on the pipe 86 on the downstream side of the high-pressure pump 37, and the joined water to be treated is supplied to the supply port 38a of the seawater reverse osmosis membrane device 38.

[0023]

In such a manner, as the non-permeate water G from the seawater reverse osmosis membrane device 38 has an extremely high pressure, the energy of the non-permeate water G is collected to be reused for energy to supply the water to be treated to the seawater reverse osmosis membrane device 38, which enables reducing the capacity of the high-pressure pump 37 and thereby saving the power requirement. Further, by mixing the non-permeate water C from the wastewater treatment system 1 with the seawater D, the salinity concentration is reduced, and the pressure increase required to the high-pressure pump 37 is reduced down to approximately 3.5 MPa by diluting the non-permeate water C and the seawater D in substantially the same amount wherein approximately 6MPa would be necessary in case of seawater only. As a result, the power requirement is reduced also in this manner. That is, as the operational pressure of the seawater reverse osmosis membrane device 38 is higher compared with the operational pressure of the low-pressure reverse osmosis membrane device 16, the energy of the non-permeate water G in the seawater reverse osmosis membrane device 38 is collected. Further, the operational pressure itself of the seawater reverse osmosis membrane device 38 is reduced.

[0024]

Incidentally, the transfer pump 12, the supply pump 14, the high-pressure pump 15, the intake pump 31, the filtration pump 33, the supply pump 36, the high-pressure pump 37, the booster pump 41, the rotor section 39a of the energy recovery device 39, and the like are connected to the rotation shaft of a driving motor, not shown, and integrally configured. An inverter device (not shown) for supplying driving power to the driving motor is installed as a site panel or integrally attached to the driving motor. The control device 6 controls the rotation of the driving motor through the inverter.

[0025]

(Control Device 6)

In the following, outline of control by the control device 6 in the present basic embodiment will be described.

The control device 6 is configured by, for example, plural control units 60, 61, and 63, wherein each of the control units 60, 61, and 63 is provided with a CPU board, an input/output interface board, and the like, wherein a CPU, a ROM, a RAM, etc., not shown, are mounted on the CPU board. The control unit 60 integrally controls the entire complex desalination system 100. The control unit 61 controls the wastewater treatment system 1. The control unit 63 controls the seawater desalination treatment system 3. Therefore, the control unit 60 is communicably connected to the control units 61 and 63.

The control unit 61 includes a flow rate control section (not shown), as a function section, for regulating the flow rate of the non-permeate water C by adjusting the opening degree of the back-pressure valve 18.

[0026]

The control unit 60 of the control device 6 has required-flow-rate instructions C1, C2 for the permeate water B and the product water E in the

complex desalination system 100, which are input thereinto from outside. Then, the control unit 60 sets a target flow rate of the permeate water B in the wastewater treatment system 1, for example, in response to the required-flow-rate instruction C1, based on the wastewater flow rate (a flow rate detected by a later-described flow rate sensor S1) supplied to the wastewater treatment system 1 and the flow rate (a flow rate detected by a later-described flow rate sensor S6) of the permeate water B, and thus has the control unit 61 control the wastewater treatment system 1. The control unit 60 also computes a target flow rate of the permeate water E in the seawater desalination treatment system 3 in response to the required flow rate instruction C2, and thus has the control unit 63 control the seawater desalination treatment system 3.

[0027]

In order to perform these, the wastewater intake pipe 51 is provided with a flow rate sensor S1 for detecting the flow rate of the wastewater A, and the pipe 54 is provided with a flow rate sensor S6 for detecting the flow rate of the permeate water B, so that the flow rate of the wastewater A and the flow rate of the permeate water B are input into the control unit 60 through the unit 61. Further, the pipe 87 is provided with a flow rate sensor S20 for detecting the flow rate of the permeate water E so that the flow rate of the permeate water E is input into the control unit 60 through the control unit 63.

[0028]

The MBR water treatment device 11 is, for example, provided with a water level sensor S2, and the control unit 61 controls start and stop of the transfer pump 12, based on a water level signal from the water level sensor S2. The treated water tank 13 is, for example, provided with a water level sensor S3, and the control unit 61 controls start and stop of the supply pump

14 and controls the rotation speed of the supply pump 14 during operation, based on a water level signal from the water level sensor S3 and a pressure signal from a pressure sensor S4 provided at the pipe 53 on the suction side of the high-pressure pump 15. This control of the rotation speed of the supply pump 14 based on a pressure signal from the pressure sensor S4 is performed in order to provide the high-pressure pump 15 with a predetermined sucking pressure.

[0029]

Further, the control unit 61 adjusts the rotation speed of the high-pressure pump 15, based on a flow rate signal of the permeate water B from the flow rate sensor S6 provided at the pipe 54, so that the flow rate becomes a target flow rate of the permeate water B having been input from the control unit 60. Further, based on a flow rate signal then from the flow rate sensor S5 provided at the pipe 53 on the discharge side of the high-pressure pump 15, the control unit 61 performs feedback control of the rotation speed of the high-pressure pump 15 so that the flow rate signal becomes constant.

Incidentally, the feedback control of the rotation speed of the high-pressure pump 15 by the control unit 61 is calibrated, as appropriate, based on the deviation between the flow rate signal of the permeate water B and the target flow rate of the permeate water B.

[0030]

The pipe 56 is provided with a flow rate sensor S7 for detecting the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16, wherein the above-described flow rate control section of the control unit 61 adjusts the opening degree of the back-pressure valve 18, based on a flow rate signal from the flow rate sensor S7, so that the flow rate

of the non-permeate water C becomes in a constant ratio to the flow rate indicated by the flow rate sensor S5 of the water to be treated.

[0031]

The intake pipe 82 is provided with a flow rate sensor S11, and the intake tank 32 is provided with a water level sensor S12. The control unit 63 controls start and stop of the intake pump 31, based on a water level signal from the water level sensor S12; sets a intake flow rate target of the seawater D, corresponding to the flow rate of the non-permeate water C discharged from the wastewater treatment system 1 to the intake tank 32; and controls the rotation speed of the intake pump 31, based on a flow rate signal from the flow rate sensor S11.

For example, in case that the flow rate of the non-permeate water C and the intake flow rate of the seawater D are made substantially the same and the non-permeate water C is mixed with the seawater D in the intake tank 32 so that the salinity concentration is decreased, the operational pressure of the seawater reverse osmosis membrane device 38 is maintained approximately at 3.5 to 4 MPa.

[0032]

Further, the control unit 63 controls start and stop of the filtration pump 33, based on a water level signal from the water level sensor S14 provided at the treated water tank 35; controls the rotation speed of the filtration pump 33 to be at a predetermined rotation speed, based on a flow rate signal from a flow rate sensor S13 provided at the pipe 84; has the water to be treated from the intake tank 32 pressure transferred to the pre-treatment filtration device 34 at a predetermined pressure and processed by a primary treatment; and has the water to be treated, processed by the primary treatment, stored in the treated water tank 35.

[0033]

Still further, the control unit 63 controls start and stop of the supply pump 36 and the rotation speed of the supply pump 36 during operation, based on a pressure signal from a pressure sensor S15 provided at the pipe 85 on the suction side of the high-pressure pump 37. The control of the rotation speed of the supply pump 36 based on a pressure signal from the pressure sensor S15 is performed in order to provide the high-pressure pump 37 with a predetermined suction pressure.

[0034]

Yet further, the control unit 63 adjusts the rotation speeds of the supply pump 36, the high-pressure pump 37, and the booster pump 41, based on a flow rate signal of the permeate water E from the flow rate sensor S20 provided at the pipe 87, so that the flow rate of the permeate water E becomes a target flow rate having been input from the control unit 60. The control unit 63 performs feedback control of the rotation speeds of the high-pressure pump 37 and the booster pump 41, based on a flow rate signal then from a flow rate sensor S16 provided at the pipe 86 on the discharge side of the high-pressure pump 37 and the booster pump 41, so that the flow rate becomes constant.

Incidentally, the feedback control of the rotation speeds of the high-pressure pump 37 and the booster pump 41 by the control unit 63 is calibrated, as appropriate, based on the deviation between the flow rate signal of the permeate water E and the target flow rate of the permeate water E.

[0035]

The pipe 89 is provided with a flow rate sensor S19 for detecting the flow rate of the non-permeate water G from the seawater reverse osmosis membrane device 38, and the control unit 63 adjusts the opening degree of the back-pressure valve 40 so that the flow rate of the non-permeate water G

becomes at a constant ratio to the flow rate indicated by the flow rate sensor S16 of the water to be treated.

[0036]

In such a manner, in the complex desalination system 100 in the basic embodiment, the non-permeate water C of the low-pressure reverse osmosis membrane device 16 discharged from the wastewater treatment system 1 is mixed with the taken-in seawater D to form a water to be treated in the seawater desalination treatment system 3. Thus, the salinity concentration of the water to be treated in the seawater desalination treatment system 3 is reduced down approximately to a half, and the operational pressure for operating the seawater reverse osmosis membrane device 38 is reduced to a great extent compared with approximate 6 MPa required in a case of treating 100% seawater only, which enables saving the power requirement.

[0037]

<<First Embodiment>>

In the following, a complex desalination system 100A according to a first embodiment of the present invention will be described, referring to FIG. 2. FIG. 2 is a schematic block diagram of the complex desalination system according to the first embodiment. The basic configuration of the complex desalination system 100A in the present embodiment is substantially the same as that of the complex desalination system 100 in the basic embodiment shown in FIG. 1, but the complex desalination system 100A is different from the complex desalination system 100 in that a control device 6 controls a later-described flow-rate control valve 19 and that a turbine pump (first pump) 33A is used as shown in FIG. 2, differently from the basic embodiment shown in FIG. 1, instead of the filtration pump 33 for supplying

a water to be treated from the intake tank 32 to the pre-treatment filtration device 34.

Incidentally, in the present embodiment, the flow rate sensor S13, which is provided in the pipe 84 in the basic embodiment in FIG. 1, is provided in a later-described pipe 83B.

[0038]

Accordingly, one end of a pipe 56 is connected to the discharge port 16c of a low-pressure reverse osmosis membrane device 16, and the other end is connected to the pressurized water inlet 33c of the turbine section 33a of the turbine pump 33A. One end of a pipe 57 is connected to the discharge port 33d of the turbine section 33a of the turbine pump 33A, and the other end is connected to an intake tank 32 through a back-pressure valve 18.

Further, one end of a pipe 83A is connected to the intake tank 32, and the other end is connected to the suction port 33e of the pump section 33b of the turbine pump 33A. One end of a pipe 83B is connected to the discharge port 33f of the pump section 33b of the turbine pump 33A, and the other end is connected to a pre-treatment filtration device 34.

Further, one end of a return pipe 83C is connected to a branch point P5 of the pipe 83B, and the other end is connected to the intake tank 32 through a flow-rate control valve 19.

A non-permeate water C from the low-pressure reverse osmosis membrane device 16 rotationally drives a turbine built in the turbine section 33a of the turbine pump 33A, and is discharged into the intake tank 32 through the back-pressure valve 18. The turbine rotationally drives pump impellers built in the pump section 33b, which sucks in the water to be treated produced by mixing a seawater (first raw water) D from the intake tank 32 and the non-permeate water C to each other, and pressurized the water to be treated to a predetermined pressure, approximately 150 kPa for

example to thereby supply the water to be treated to a pre-treatment filtration device 34 through the pipe 83B.

[0039]

The control units 60 and 61 of the control device 6 in the present embodiment have the same functions as those of the control units 60 and 61 of the control device 6 of the complex desalination system 100 in the basic embodiment. The function of the control unit 63 of the control device 6 in the present embodiment is substantially the same as the function of the control unit 63 of the control device 6 of the complex desalination system 100, but is different in that a function to control the filtration pump 33 is not provided but a function to adjust the opening degree of a flow-rate amount control valve 19 is provided. The same symbols are assigned to the same elements as those of the complex desalination system 100, and a redundant description will be omitted. Also, a redundant description of the same control functions as those of the control device 6 in the basic embodiment will be omitted.

[0040]

The flow rate control section (not shown), as a function section, of the control unit 61 in the present embodiment controls the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16. As the turbine inlet pressure {displayed as ‘turbine inlet pressure (pressurizing pressure of the non-permeate water) the first left column in TABLE 1’} applied at the pressurized water inlet 33c of the turbine pump 33A by the non-permeate water C from the low-pressure reverse osmosis membrane device 16 increases, the turbine inlet flow rate (liter/min) {described as ‘turbine inlet flow rate (flow rate of the non-permeate water)’ in the second left column in Table 1} also correspondingly increases. Herein, when the turbine inlet flow rates with

respect to the respective values of the turbine inlet pressure of the non-permeate water C from the low-pressure reverse osmosis membrane device 16 are referred to as 100%, the discharge flow rates (%) of the water to be treated corresponding to the discharge pressure (kPa) of the water to be treated from the discharge port 33f of the pump section 33b of the turbine pump 33A become values larger than the turbine inlet flow rates (%).

[0041]

As the opening degree of the back-pressure valve 18 is controlled by the above-described flow rate control section of the control unit 61 to control the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16, the discharge flow-rate from the pump section 33b of the turbine pump 33A is automatically determined by the hydraulic pressure and the flow rate of the non-permeate water C. In order to regulate with high accuracy the flow rate of the water to be treated to be supplied to the pre-treatment filtration device 34 by the rotation speed of the turbine pump 33A, the control unit 63 is provided with a flow rate control section (not shown) as a function section, wherein in case that the supply rate of the water to be treated by the turbine pump 33A to the pre-treatment filtration device 34 is too large, the opening degree of the flow-rate control valve 19 is adjusted, based on a flow rate signal from the flow rate sensor S13, and a surplus water to be treated is returned to the intake tank 32 through a return pipe 83C.

Accordingly, similarly to the complex desalination system 100 in the basic embodiment, in case that the intake rate of the seawater D by the seawater desalination treatment system 3 is approximately 0.5 times the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16, a filtration pump 33 is not necessary and the complex desalination system 100A reduces the corresponding cost of driving force.

[0042]

[TABLE 1]

Turbine Inlet Pressure (Pressurized Pressure of Non-permeate Water) (kPa)	Turbine Inlet Flow Rate (Flow Rate of Non-permeate Water) (%)	Characteristics of Discharge Pressure of Water to be treated vs. Discharge Flow Rate of Water to be treated (Discharge Flow Rate (%) Corresponding to Discharge Pressure (kPa) Represented by Percentage)		
		80kPa	100kPa	150kPa
600	100%	150%	130%	100%
800	100%	160%	150%	120%
1000	100%	180%	170%	150%

[0043]

<<Second Embodiment>>

In the following, referring to FIG. 3, a complex desalination system 100B according to a second embodiment of the present invention will be described. FIG. 3 is a schematic block diagram of the complex desalination system according to the second embodiment. The complex desalination system 100B in the present embodiment is different from the complex desalination system 100A in that the control unit 63 of a control device 6 controls a later-described auxiliary filtration pump (second pump) 33B and that a further pipe 83D is connected from an intake tank 32 to a junction point P6 with the pipe 83B, as shown in FIG. 3 wherein the pipe 83D is provided with an auxiliary filtration pump 33B.

The control device 6 includes a control unit 60, a control unit 61, and the control unit 63, similarly to the first embodiment.

[0044]

The function of the control unit 63 is basically the same as that of the control unit 63 in the first embodiment. However, in case that the supply rate of the water to be treated by a turbine pump 33A to a pre-treatment filtration device 34 is too large, a flow rate control section (not shown) as the function section adjusts the opening degree of a flow-rate control valve 19, based on a flow rate signal from a flow rate sensor S13 and returns a surplus water to be treated to an intake tank 32 through a return pipe 83C.

Conversely, in case that the supply rate of the water to be treated by the turbine pump 33A to the pre-treatment filtration device 34 is small, the above-described flow rate control section of the control unit 63 starts an auxiliary filtration pump 33B, and controls the rotation speed of a motor not shown that drives the auxiliary filtration pump 33B, based on a flow rate signal from the flow rate sensor S13 so that the total supply rate of the water to be treated by the turbine pump 33A and the auxiliary filtration pump 33B becomes a predetermined flow rate.

[0045]

Incidentally, the pump capacity of the auxiliary filtration pump 33B is smaller than the pump capacity of the filtration pump 33 in the basic embodiment, and the power requirement in operating the auxiliary filtration pump 33B is reduced from the power requirement in the case of the basic embodiment.

[0046]

In the above description, the flow rate control section of the control unit 63 performs start and stop of the auxiliary filtration pump 33B, control of the rotation speed of the auxiliary filtration pump 33B in operation, and adjustment of the opening degree of the flow-rate control valve 19, based on a flow-rate signal from the flow-rate sensor S13 provided at the pipe 83B on

the downstream side of the junction point P6, however, arrangement is not limited thereto.

Instead of providing the flow rate sensor S13, arrangement may be made such that a flow rate sensor S13A is provided in the pipe 83B on the upstream side of a junction point P5; a flow rate sensor 13B is provided in the pipe 83D on the downstream side of the auxiliary filtration pump 33B; and the above-described flow rate control section of the control unit 63 performs control by determining a flow rate of the water to be treated to be supplied to the pre-treatment filtration device 34, based on respective flow rate signals from the flow rate sensors S13A and S13B. That is, in case that a flow rate indicated by the flow rate sensor S13A is larger than or equal to a predetermined flow rate, the auxiliary filtration pump 33B is made in a stop state, and the flow rate of the water to be treated to be supplied to the pre-treatment filtration device 34 is controlled by adjusting the opening degree of the flow-rate control valve 19. Conversely, in case that a flow rate indicated by the flow rate sensor S13A is smaller than the predetermined flow rate, the flow-rate control valve 19 is completely closed and the auxiliary filtration pump 33B is started. Then, the rotation speed of the auxiliary filtration pump 33B is controlled so that the total value of a flow rate indicated by the flow rate sensor S13A and a flow rate indicated by the flow rate sensor S13B becomes the predetermined flow rate, and the flow rate of the water to be treated to be supplied to the pre-treatment filtration device 34 is thus controlled.

[0047]

According to the present embodiment, in either case that the flow rate of the water to be treated supplied from the intake tank 32 by the turbine pump 33A driven by the non-permeate water C is larger or smaller than the predetermined flow rate of the water to be treated to be supplied to

the pre-treatment filtration device 34, the flow rate is flexibly controlled by the above-described flow rate control section of the control unit 63, which thereby achieves a target flow rate of the product water E.

[0048]

<<Third and Fourth Embodiments>>

(Third Embodiment)

In the following, referring to FIG. 4, a complex desalination system 100C according to a third embodiment of the present invention will be described. FIG. 4 is a schematic block diagram of the complex desalination system according to the third and fourth embodiments.

The basic configuration of the complex desalination system 100C in the third embodiment is the same as that of the complex desalination system 100 in the basic embodiment. However, the complex desalination system 100C is different from the complex desalination system 100 in that a control unit 63 of a control device 6 controls a later-described turbine pump (third pump) 33A instead of an intake pump 31, and that the turbine pump 33A is used instead of an intake pump 31 for taking in seawater D into an intake tank 32, as shown in FIG. 3 differently from the basic embodiment shown in FIG. 1.

Incidentally, in the present embodiment, the flow rate sensor S13, which is provided in the pipe 84 in the basic embodiment shown in FIG. 1, is provided in a pipe 83 on the discharge side of a filtration pump 33.

[0049]

Accordingly, as shown in FIG. 4, one end of a pipe 56 is connected to the discharge port 16c of a low-pressure reverse osmosis membrane device 16, and the other end is connected to the pressurized water inlet 33c of the turbine section 33a of the turbine pump 33A. One end of a pipe 57 is connected to the discharge port 33d of the turbine section 33a of the turbine

pump 33A, and the other end is connected to an intake tank 32 with a back-pressure valve 18 interposed therebetween.

Further, an intake pipe 81 is connected to the suction inlet 33e of the pump section 33b of the turbine pump 33A. One end of an intake pipe 82C is connected to the discharge port 33f of the pump section 33b of the turbine pump 33A, and the other end is connected to an intake tank 32.

A non-permeate water C from the low-pressure reverse osmosis membrane device 16 rotationally drives a turbine built in the turbine section 33a of the turbine pump 33A, and is discharged into the intake tank 32 through the back-pressure valve 18. The turbine rotationally drives pump impellers built in the pump section 33b, which sucks in a seawater (first raw water) D through the intake pipe 81 to supply the seawater D through an intake pipe 82C to the intake tank 32.

[0050]

The functions of the control device 6 are substantially the same as the functions of the control device 6 of the complex desalination system 100 in the basic embodiment, and the control device 6 includes a control unit 60, a control unit 61, and a control unit 63.

The same symbols are assigned to the same elements as those of the complex desalination system 100, and a redundant description will be omitted. Also, a redundant description of the same control functions as those of the control device 6 in the basic embodiment will be omitted.

[0051]

The flow rate control section (not shown) as the function section of the control unit 61 has the same function as the control unit 61 in the basic embodiment, and controls the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16. Corresponding to an increase in the turbine inlet pressure of the non-permeate water C from

the low-pressure reverse osmosis membrane device 16 applied at the pressurized water inlet 33c of the turbine pump 33A, the turbine inlet flow rate (liter/min) of the non-permeate water C from the low-pressure reverse osmosis membrane device 16 also increases. Herein, as shown by TABLE 1 (though 'the characteristics of the discharge pressure of the water to be treated vs. the discharge flow rate of the water to be treated' shown in the columns after the second left column in TABLE 1 should be read as 'characteristics of the discharge pressure of the seawater vs. the discharge flow rate of the seawater'), when the turbine inlet flow rates with respect to the respective values of the turbine inlet pressure of the non-permeate water C from the low-pressure reverse osmosis membrane device 16 are referred to as 100%, the discharge flow rates (%) of the seawater corresponding to the discharge pressure (kPa) of the seawater from the discharge port 33f of the pump section 33b of the turbine pump 33A become values larger than the turbine inlet flow rates (%) of the non-permeate water C.

When the turbine inlet flow rates with respect to the respective values of the turbine inlet pressure are standardized as 100%, the discharge flow rates (%) of the seawater D corresponding to the discharge pressure (kPa) of the seawater D from the discharge port 33f of the pump section 33b of the turbine pump 33A become values larger than the turbine inlet flow rates (%) of the non-permeate water C from the low-pressure reverse osmosis membrane device 16.

[0052]

As the opening degree of the back-pressure valve 18 is controlled by the flow rate control section (not shown) as the function section of the control unit 61 in order to control the flow rate of the non-permeate water C from the low-pressure reverse osmosis membrane device 16, the discharge amount of the pump section 33b of the turbine pump 33A is automatically determined

by the hydraulic pressure and the flow rate of the non-permeate water C. In this situation, as solution in case that the turbine pump 33A has excessively taken in the seawater D to be supplied to the intake tank 32, the intake tank 32 is provided with an overflow outlet (not shown) so as to discharge the excessive seawater D having been taken in by the turbine pump 33A.

Accordingly, an intake pump 31, which is necessary for the complex desalination system 100 in the basic embodiment, is unnecessary, and the complex desalination system 100C thus enables reduction in the power requirement.

[0053]

Incidentally, although the function of the control unit 63 is basically the same as that of the control unit 63 in the basic embodiment, the control unit 63 is not provided with a function to control the intake rate of the seawater D, based on a water level signal from a flow rate sensor S11 and a water level sensor S12.

[0054]

(Fourth Embodiment)

In the following, referring to FIG. 4, a complex desalination system 100D according to a fourth embodiment of the present invention will be described. The complex desalination system 100D is different from the complex desalination system 100C in that the control unit 63 of a control device 6 controls a later-described auxiliary intake pump (fourth pump) 31A; further, an intake pipe 81D is branched from an intake pipe 81, as shown by a dashed line in FIG. 4; the intake pipe 81D is connected to the suction inlet of the auxiliary intake pump 31A, and further, an intake pipe 82D is connected to the discharge outlet of the auxiliary intake pump 31A and connected to an intake tank 32; and a flow rate sensor S35 is provided in the

intake pipe 81, as shown by a dashed line in FIG. 4, and the intake flow rate of the seawater D is detected and a flow rate signal is input into the control device 6.

The control device 6 includes a control unit 60, a control unit 61, and a control unit 63, similarly to the third embodiment.

[0055]

Although the function of the control unit 63 is basically the same as that of the control unit 63 in the third embodiment, the control unit 63 has a function to control the intake rate of the seawater D, based on a water level sensor S12 and a flow rate sensor S35, similarly to the control unit 63 in the basic embodiment.

In case that the intake rate, indicated by the flow rate sensor S35, of the seawater D by the turbine pump 33A into the intake tank 32 is small, the flow rate control section as the function section of the control unit 63 starts an auxiliary intake pump 31A, and controls the rotation speed of a motor not shown that drives the auxiliary intake pump 31A, based on a flow rate signal from the flow rate sensor S35 so that the total intake amount of the seawater D by the turbine pump 33A and the auxiliary intake pump 31A becomes a required intake rate.

[0056]

Incidentally, the pump capacity of the auxiliary intake pump 31A is smaller than the pump capacity of the intake pump 31 in the basic embodiment, and the power requirement in operating the auxiliary intake pump 31A is reduced from the power requirement in the case of the basic embodiment.

[0057]

According to the present embodiment, even in case that the intake rate of the seawater D supplied by the turbine pump 33A, which is driven by

the non-permeate water C, into the intake tank 32 is lower than a predetermined flow rate, the intake rate of the seawater D is controlled by the above-described flow rate control section of the control unit 63, and a target flow rate of the product water E is achieved.

[0058]

As has been described above, according to the first to fourth embodiments, as the pressure of the non-permeate water C of a wastewater treatment system 1, the pressure of the non-permeate water C being a comparatively low pressure of 0.8 to 1.5 MPa, is collected and is used as driving energy of the turbine pump 33A. Therefore, the complex desalination systems 100A to 100D, which reduce the power requirement more than a conventional one, are provided.

[0059]

Although, in the first to fourth embodiments, the energy recovery device 39 in FIGS. 2 to 4 is described as one of a direct pressure exchange type and is combined with the booster pump 41 at the subsequent stage, the arrangement is not limited thereto. An arrangement may be made such as to drive a turbo-charger pump by a non-permeate water G. In this case, the pipe 89 and the pipe 90 are respectively connected to the inlet and outlet of the turbine section (driving section) of the turbo-charger pump; the downstream side of the pipe 86 is connected to the inlet of the pump section of the turbo-charger pump; and the outlet of the pump section of the turbo-charger pump is connected to the supply port 38a by a pipe. Also in such an arrangement, the pressure of the non-permeate water G is collected.

Incidentally, the pipes 91 and 92 and the booster pump 41 are unnecessary in this case.

[0060]

Further, although, in the first to fourth embodiments, an example has been described in which the non-permeate water C is introduced from the low-pressure reverse osmosis membrane device 16 into the intake tank 32, an arrangement is not limited thereto.

In the first and second embodiments, the most downstream side tip end of the pipe 57 may be directly connected to the intake pipe 82 to mix, in the pipe 82, the non-permeate water C from the low-pressure reverse osmosis membrane device 16 and the seawater D and thereby form a water to be treated.

Still further, in the third and fourth embodiments, an arrangement may be made such that the most downstream side tip end of the pipe 57 is directly connected to pipe 81 at a point on the downstream side of the flow rate sensor S35, the pipe 81 being on the suction side of the turbine pump 33A or the auxiliary intake pump 31A, to mix, in the pipe 81, the non-permeate water C from the low-pressure reverse osmosis membrane device 16 and the seawater D and thereby form a water to be treated.

[0061]

In the basic and first to fourth embodiments, a product water B and a product water E are supplied to outside, corresponding to the respective water quality levels, however, the product water B and the product water E may also be mixed and then supplied to outside.

Description of Reference Numerals

[0062]

- 1 wastewater treatment system (second water treatment system)
- 3 seawater desalination treatment system (first water treatment system)
- 6 control device
- 11 MBR water treatment device

12 transfer pump

13 treated water tank

14 supply pump

15 high-pressure pump

16 low-pressure reverse osmosis membrane device (second reverse osmosis membrane device)

16c discharge port

18 back-pressure valve

19 flow-rate control valve

31 intake pump

31A auxiliary intake pump (fourth pump)

32 intake tank (first raw water tank)

33 filtration pump

33A turbine pump (first pump, third pump)

33B auxiliary filtration pump (second pump)

34 pre-treatment filtration device (preliminary filtration device)

35 treated water tank

36 supply pump

37 high-pressure pump

38 seawater reverse osmosis membrane device (first reverse osmosis membrane device)

39 pressure exchange device

40 back-pressure valve

41 booster pump

60 control unit

61 control unit

63 control unit

81, 81D, 82, 82C, 82D intake pipe

83C return pipe

100, 100A, 100B, 100C, 100D complex desalination system

A wastewater (second raw water)

D seawater (first raw water)

CLAIMS

1. A complex desalination system, comprising:
 - a first water treatment system for filtering a first raw water having a high salinity concentration by use of a first reverse osmosis membrane device; and
 - a second water treatment system for filtering a second raw water having a salinity concentration lower than the salinity concentration of the first raw water by use of a second reverse osmosis membrane device,
 - the first water treatment system comprising:
 - a preliminary filtration device for filtering a water to be treated including the first raw water taken in, in a stage preliminary to the first reverse osmosis membrane device; and
 - a first pump for pressurizing the water to be treated to be supplied to the preliminary filtration device,
 - wherein the first pump is driven under a hydraulic pressure by a non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system, and
 - wherein the non-permeate water having driven the first pump is mixed with the first raw water to produce the water to be treated.
2. The complex desalination system according to claim 1,
 - the first water treatment system comprising:
 - a first raw water tank storing the first raw water taken in,
 - wherein the non-permeate water having driven the first pump is mixed with the first raw water stored in the first raw water tank to produce the water to be treated.

3. The complex desalination system according to claim 2,
the first water treatment system comprising:
a second pump for pressurizing the water to be treated from the first raw water tank to supply the water to be treated to the preliminary filtration device, the second pump being arranged in parallel with the first pump.
4. The complex desalination system according to claim 1,
the first water treatment system comprising:
a flow rate control valve for regulating a flow rate of the water to be treated to be supplied to the preliminary filtration device.
5. The complex desalination system according to claim 2,
the first water treatment system comprising:
a flow rate control valve for regulating a flow rate of the water to be treated to be supplied to the preliminary filtration device.
6. The complex desalination system according to claim 3,
the first water treatment system comprising:
a flow rate control valve for regulating a flow rate of the water to be treated to be supplied to the preliminary filtration device.
7. The complex desalination system according to claim 4,
wherein the flow rate control valve is provided to a return pipe which connects a supply port side, for the water to be treated, of the preliminary filtration device and the first raw water tank to each other.
8. The complex desalination system according to claim 5,

wherein the flow rate control valve is provided to a return pipe which connects a supply port side, for the water to be treated, of the preliminary filtration device and the first raw water tank to each other.

9. The complex desalination system according to claim 6,
wherein the flow rate control valve is provided to a return pipe which connects a supply port side, for the water to be treated, of the preliminary filtration device and the first raw water tank to each other.

10. A complex desalination system, comprising:
a first water treatment system for filtering a first raw water having a high salinity concentration by use of a first reverse osmosis membrane device; and

a second water treatment system for filtering a second raw water having a salinity concentration lower than the salinity concentration of the first raw water by use of a second reverse osmosis membrane device,

the first water treatment system comprising:

a third pump for taking in the first raw water; and

a first raw water tank storing the first raw water taken in,

wherein the third pump is driven under a hydraulic pressure by a non-permeate water discharged from the second reverse osmosis membrane device of the second water treatment system, and

wherein the non-permeate water having driven the third pump is supplied to the first raw water tank.

11. The complex desalination system according to claim 10,
the first water treatment system further comprising:

a fourth pump for taking in the first raw water and transferring the first raw water to the first raw water tank, the fourth pump being arranged in parallel with the third pump.