separation in the first module to the second module; a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module; a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path; a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path; a power detector for detecting consumption power of the high pressure pump; a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result of the power detector.

According to a second aspect of the present invention, there is provided a desalination apparatus comprising: a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane; a first flow path for supplying the raw water to the first module; a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane; a second flow path for supplying the first permeate water after separation in the first module to the second module; a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module; a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path; a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path; a pressure detector provided downstream of the high pressure pump in the first flow path; a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water

flowing through the fourth flow path; and a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result of the pressure detector.

According to a third aspect of the present invention, there is provided a desalination apparatus comprising: a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane; a first flow path for supplying the raw water to the first module; a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane; a second flow path for supplying the first permeate water after separation in the first module to the second module; a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module; a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path; a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path; a salt concentration detector provided in the first flow path or in another flow path upstream of the first module to detect salt concentration of water; a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result of the salt concentration detector.

According to a fourth aspect of the present invention, there is provided a desalination apparatus comprising: a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane; a first flow path for supplying the raw water to the first module; a second module for separating the first permeate water after separation in

the first module into second permeate water and second concentrated water by a reverse osmosis membrane; a second flow path for supplying the first permeate water after separation in the first module to the second module; a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module; a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path; a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path; a first salt concentration detector for detecting a salt concentration WA1 of the second concentrated water; a first flow rate detector for detecting a water flow rate FT1 in the third flow path; a second salt concentration detector for detecting a salt concentration WA2 of the first concentrated water; a second flow rate detector for detecting a water flow rate FT2 in the fourth flow path; a third salt concentration detector for detecting a salt concentration WA3 in the first flow path before merging with the third flow path and the fourth flow path; a third flow rate detector for detecting a water flow rate FT3 in the first flow path before merging with the third flow path and the fourth flow path; a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and a control unit which determines a salt concentration of water flowing into the high pressure pump by calculating "(WA1 × FT1 + WA2 × FT2 + WA3 × FT3) / (FT1 + FT2 + FT3)", and controls the flow controller based on the determined salt concentration to adjust the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path.

According to a fifth aspect of the present invention, there is provided a desalination apparatus comprising: a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane; a first flow path for supplying the raw water to the first module; a second module for separating the first permeate water after separation in

the first module into second permeate water and second concentrated water by a reverse osmosis membrane; a second flow path for supplying the first permeate water after separation in the first module to the second module; a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module; a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path; a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path; a first flow rate detector for detecting a water flow rate in the first flow path; a fifth flow path through which the first concentrated water flows; a second flow rate detector for detecting a water flow rate in the fifth flow path; a third flow rate detector for detecting a water flow rate in the second flow path; a fourth flow rate detector for detecting a water flow rate FT1 in the third flow path; a sixth flow path through which the second permeate water flows; a fifth flow rate detector for detecting a water flow rate in the sixth flow path; a sixth flow rate detector for detecting a water flow rate FT2 in the fourth flow path; a third salt concentration detector for detecting a salt concentration WA3 in the first flow path before merging with the third flow path and the fourth flow path; a seventh flow rate detector for detecting a water flow rate FT3 in the first flow path before merging with the third flow path and the fourth flow path; a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and a control unit which estimates a salt concentration N1 of the first concentrated water from flow distribution of the water flow rate detected by the first flow rate detector between the first permeate water detected by the third flow rate detector and the first concentrated water detected by the second flow rate detector, estimates a salt concentration N2 of the second concentrated water from flow distribution of a flow rate of the first permeate water detected by the third flow rate detector between the second permeate water detected by the fifth

flow rate detector and the second concentrated water detected by the fourth flow rate detector, and controls the flow controller to adjust the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path so that the salt concentration of water on a suction side of the high pressure pump obtained by calculating "(N1 × FT2 + N2 × FT1 + WA3 × FT3) / (FT1 + FT2 + FT3)" is a predetermined value.

[Advantageous Effects of Invention]

[0008]

According to embodiments of the present invention, it is possible to provide a desalination apparatus in which a high pressure pump can be operated at a high efficient operation point even when temperature, salt concentration or the like of water to be treated vary. Problems, configurations and effects other than those described above will be apparent from the following description of embodiments.

[Brief Description of Drawings]

[0009]

FIG. 1 is a system diagram of a desalination apparatus according to an embodiment 1 of the present invention;

FIG. 2 is a system diagram of a desalination apparatus according to an embodiment 2 of the present invention;

FIG. 3 is a system diagram of a desalination apparatus according to an embodiment 3 of the present invention;

FIG. 4 is a system diagram of a desalination apparatus according to an embodiment 4 of the present invention;

FIG. 5 is a system diagram of a desalination apparatus according to an embodiment 5 of

CLAIMS

1. A desalination apparatus comprising:

a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane;

a first flow path for supplying the raw water to the first module;

a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane;

a second flow path for supplying the first permeate water after separation in the first module to the second module;

a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module;

a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path;

a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path;

a power detector for detecting consumption power of the high pressure pump;

a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and

a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result of the power detector.

2. A desalination apparatus comprising:

a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane;

a first flow path for supplying the raw water to the first module;

a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane;

a second flow path for supplying the first permeate water after separation in the first module to the second module;

a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module;

a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path;

a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path;

a pressure detector provided downstream of the high pressure pump in the first flow path;

a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and

a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result

of the pressure detector.

3. A desalination apparatus comprising:

a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane;

a first flow path for supplying the raw water to the first module;

a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane;

a second flow path for supplying the first permeate water after separation in the first module to the second module;

a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module;

a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path;

a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path;

a salt concentration detector provided in the first flow path or in another flow path upstream of the first module to detect salt concentration of water;

a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and

a control unit for controlling the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path by the flow controller based on a detection result of the salt concentration detector.

4. A desalination apparatus comprising:

a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane;

a first flow path for supplying the raw water to the first module;

a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane;

a second flow path for supplying the first permeate water after separation in the first module to the second module;

a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module;

a third flow path for supplying the second concentrated water after separation in the second module to upstream of the high pressure pump in the first flow path;

a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path;

a first salt concentration detector for detecting a salt concentration WA1 of the second concentrated water;

a first flow rate detector for detecting a water flow rate FT1 in the third flow path;

a second salt concentration detector for detecting a salt concentration WA2 of the first concentrated water;

a second flow rate detector for detecting a water flow rate FT2 in the fourth flow path;

a third salt concentration detector for detecting a salt concentration WA3 in the first flow path before merging with the third flow path and the fourth flow path;

a third flow rate detector for detecting a water flow rate FT3 in the first flow path before merging with the third flow path and the fourth flow path;

a flow controller provided in the fourth flow path to adjust a flow rate of the first concentrated water flowing through the fourth flow path; and

a control unit which determines a salt concentration of water flowing into the high pressure pump by calculating "(WA1 × FT1 + WA2 × FT2 + WA3 × FT3) / (FT1 + FT2 + FT3)", and controls the flow controller based on the determined salt concentration to adjust the flow rate of the first concentrated water flowing into the first flow path through the fourth flow path.

5. A desalination apparatus comprising:

a first module for separating raw water into first permeate water and first concentrated water by a reverse osmosis membrane;

a first flow path for supplying the raw water to the first module;

a second module for separating the first permeate water after separation in the first module into second permeate water and second concentrated water by a reverse osmosis membrane;

a second flow path for supplying the first permeate water after separation in the first module to the second module;

a high pressure pump which is provided in the first flow path and supplies the raw water to the first module at high pressure to apply reverse osmotic pressure to the first module and the second module;

a third flow path for supplying the second concentrated water after separation in the

second module to upstream of the high pressure pump in the first flow path;

a fourth flow path for supplying a portion of the first concentrated water after separation in the first module to upstream of the high pressure pump in the first flow path;

a first flow rate detector for detecting a water flow rate in the first flow path;

a fifth flow path through which the first concentrated water flows;

a second flow rate detector for detecting a water flow rate in the fifth flow path;

a third flow rate detector for detecting a water flow rate in the second flow path;

a fourth flow rate detector for detecting a water flow rate FT1 in the third flow path;

a sixth flow path through which the second permeate water flows;

a fifth flow rate detector for detecting a water flow rate in the sixth flow path;

a sixth flow rate detector for detecting a water flow rate FT2 in the fourth flow path;

a third salt concentration detector for detecting a salt concentration WA3 in the first flow path before merging with the third flow path and the fourth flow path;

a seventh flow rate detector for detecting a water flow rate FT3 in the first flow path before merging with the third flow path and the fourth flow path;