

MARINE FRESH WATER GENERATOR

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The present invention relates to a marine fresh water generator.

2. DESCRIPTION OF THE RELATED ART

[0002] In a marine fresh water generator, fresh water is conventionally produced by evaporating seawater, using, as a heat source, steam from a boiler installed in a ship, cooling water for a diesel engine installed in the ship, or the like (for example, see Patent Document 1).

[0003] Patent Document 1: JP 7129041 B2

SUMMARY OF THE INVENTION

[0004] Fresh water generated in a ship such as a chemical ship is also used for cleaning a tank or the like installed in the ship. However, purified water having a purity higher than that of fresh water is often required when final cleaning is performed. Thus, pure water is conventionally produced, using a pure water generator including an ion-exchange membrane or an ion-exchange resin, provided separately from a fresh water generator.

[0005] However, installation of both the fresh water generator and the pure water generator in a ship may require an excessive occupation space in the ship as well as it may impose an excessive economic burden on a user.

[0006] It is therefore an object of the present invention to provide a marine fresh water generator capable of efficiently producing water having purity required for a ship with a compact configuration.

[0007] The object of the present invention is achieved by a marine fresh water generator including a first evaporator configured to heat seawater to generate first vapor, a second evaporator configured to heat first distilled water obtained by condensing the first vapor to generate second vapor, and a condenser configured to generate second distilled water obtained by condensing the second vapor, in which the first distilled water and the second distilled water can be collected from the second evaporator and the condenser, respectively.

[0008] In the marine fresh water generator, a plurality of the first evaporators is preferably provided, and is preferably configured to have multiple effects to allow the first vapor generated in at least one preceding one of the plurality of the first evaporators to be supplied as a heating source of at least one subsequent one of the plurality of the first evaporators. The first distilled water preferably includes distilled water obtained from the first vapor supplied as a heating

source to a last one of the plurality of the first evaporators and distilled water obtained from the first vapor supplied as a heating source to the second evaporator.

[0009] A switching device is preferably further provided that is capable of switching a heating target of the second evaporator to allow vapor generated in the second evaporator to be changed from the second vapor to the first vapor.

[0010] A first circulation device is preferably further provided that is configured to detect purity of the first distilled water collected from the second evaporator, and that is configured to return the first distilled water to the first evaporator to cause the first distilled water to be reheated along with the seawater when the purity that has been detected is not desired purity.

[0011] A second circulation device is preferably further provided that is configured to detect purity of the second distilled water collected from the condenser, and that is configured to return the second distilled water to the second evaporator to cause the second distilled water to be reheated along with the first distilled water when the purity that has been detected is not desired purity.

[0012] According to the marine fresh water generator of the present invention, it is possible to efficiently produce water having purity required for a ship with a compact configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a schematic configuration diagram of a marine fresh water generator according to an embodiment of the present invention;

FIG. 2 is a configuration diagram of relevant part of a marine fresh water generator according to another embodiment of the present invention;

FIG. 3 is a schematic configuration diagram of a marine fresh water generator according to still another embodiment of the present invention; and

FIG. 4 is a schematic configuration diagram of a marine fresh water generator according to yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Hereinafter, an embodiment of the present invention will be described with reference to the accompanying drawing. FIG. 1 is a schematic configuration diagram of a marine fresh water generator according to an embodiment of the present invention. A marine fresh water generator 1 according to the present embodiment includes a plurality of first evaporators 10, a second evaporator 20, and a condenser 30. The ship in which the marine fresh water generator 1 is installed is not necessarily limited. However, the marine fresh water generator 1 is preferably installed, in a suitable manner, in a ship requiring high-purity water, and examples thereof

include a chemical ship, a turbine ship, and an LNG carrier.

[0015] The plurality of first evaporators 10 is configured to have multiple effects to allow vapor generated in each preceding one of the first evaporators 10 to be supplied as a heating source of a corresponding subsequent one of the first evaporators 10. The first evaporator 10 at the first stage can use, as a heating source thereof, steam from a boiler installed in the ship, cooling water for a diesel engine installed in the ship, or the like. Although the four first evaporators 10 are illustrated in FIG. 1, the number of effects of the first evaporators 10 is not particularly limited.

[0016] Each of the first evaporators 10 includes a cylindrical container body 11 extending vertically, and a cylindrical housing 16 extending horizontally while being provided on top of the container body 11. A lower opening and an upper opening of the container body 11 are respectively covered with a bottom plate 12 and a closing plate 13 to form an evaporation chamber 11a inside the container body 11. In each of the bottom plate 12 and the closing plate 13, a plurality of insertion holes is formed, and a plurality of heat transfer tubes 15, extending vertically to pass through the insertion holes, is disposed in the evaporation chamber 11a.

[0017] An introduction portion 14 is connected, on the lower surface side of the bottom plate 12. The introduction portion 14 is formed in a tray shape, and the inside of the introduction portion 14 communicates with lower end portions of the heat transfer tubes 15. The introduction portion 14 of the first evaporator 10 at the first stage receives introduction of seawater, which flows upward through the insides of the heat transfer tubes 15.

[0018] As described above, a heating source such as steam or hot water generated in the ship is introduced into the evaporation chamber 11a of the first evaporator 10 at the first stage. The heating source heats, in the evaporation chamber 11a, the seawater passing through the insides of the heat transfer tubes 15 to generate vapor. Then, the heating source is discharged to the outside of the evaporation chamber 11a. In each of the first evaporators 10 at the second and subsequent stages, the evaporation chamber 11a thereof receives, as a heating source, vapor (first vapor) introduced via a connection tube 17 after being generated in the first evaporator 10 at the corresponding immediately preceding stage.

[0019] The housing 16 is connected to an upper end of the container body 11 with the closing plate 13 interposed therebetween, and a vapor-liquid (vapor-water) separation chamber 16a is formed inside the housing 16. In the vapor-liquid separation chamber 16a, the demister 16b is provided. The demister 16b is a flat plate-shaped member including layered mesh plates, and is horizontally supported in the vapor-liquid separation chamber 16a. In the housing 16 of the first evaporator 10 at the last stage, a first supply portion 18 is formed through which distilled water whose purity has been further increased in the second evaporator 20 described later can be

recirculated.

[0020] In an upper portion of the vapor-liquid separation chamber 16a, a vapor discharge port 16c is formed that allows the generated vapor to be discharged therethrough toward the first evaporator 10 at the immediately subsequent stage. In a lower portion of the vapor-liquid separation chamber 16a, a water discharge port 16d is formed that allows seawater separated from the vapor to be discharged therethrough. The seawater discharged through the water discharge port 16d is introduced into the introduction portion 14 of the first evaporator 10 at the immediately subsequent stage.

[0021] The second evaporator 20 is configured similarly to the first evaporator 10, and includes a cylindrical container body 21 extending vertically, and a cylindrical housing 26 extending horizontally while being provided on top of the container body 21.

[0022] A lower opening and an upper opening of the container body 21 are respectively covered with a bottom plate 22 and a closing plate 23 to form an evaporation chamber 21a inside the container body 21. In each of the bottom plate 22 and the closing plate 23, a plurality of insertion holes is formed, and a plurality of heat transfer tubes 25, extending vertically to pass through the insertion holes, is disposed in the evaporation chamber 21a.

[0023] An introduction portion 24 is connected, on the lower surface side of the bottom plate 22. The introduction portion 24 is formed in a tray shape, and the inside of the introduction portion 24 communicates with lower end portions of the heat transfer tubes 25. The introduction portion 24 receives introduction of first distilled water that has been obtained by condensing the vapor (first vapor) and that has been then discharged from the evaporation chamber 11a of the first evaporator 10 at the last stage. The evaporation chamber 21a receives, as a heating source, the vapor (first vapor) introduced via a connection tube 27 after being generated in the first evaporator 10 at the last stage. The introduced vapor heats the first distilled water flowing upward through the insides of the heat transfer tubes 25, thereby generating vapor (second vapor) of the first distilled water.

[0024] The housing 26 is connected to an upper end of the container body 21 with the closing plate 23 interposed therebetween, and a vapor-liquid separation chamber 26a is formed inside the housing 26. In the vapor-liquid separation chamber 26a, a demister 26b is provided. The demister 26b is a flat plate-shaped member including layered mesh plates, and is horizontally supported in the vapor-liquid separation chamber 26a. In a lower portion of the vapor-liquid separation chamber 26a, a first collection port 26c is formed that allows the distilled water (first distilled water) separated from the vapor (second vapor) to be discharged therethrough. In the housing 26, a second supply portion 28 is formed through which distilled water whose purity has been further increased in the condenser 30 described later can be recirculated.

[0025] The condenser 30 is provided inside the housing 26. The condenser 30 includes a condensation chamber 31 communicating with the vapor-liquid separation chamber 26a, and a condensation tube 32 disposed inside the condensation chamber 31 and allowing seawater to pass therethrough. In an upper portion of the condensation chamber 31, a vapor extraction port 33 is formed. In a lower portion of the condensation chamber 31, a second collection port 34 is formed that collects distilled water (second distilled water) generated by condensing vapor (second vapor) in the condensation chamber 31.

[0026] In the marine fresh water generator 1 having the above configuration, seawater is supplied to the condensation tube 32 of the condenser 30 via an ejector 40 by operation of a pump 41 to condense the vapor (second vapor) in the condensation chamber 31. Part of seawater having passed through the condensation chamber 31 passes through each preheating chamber 19 of the first evaporators 10 to be preheated by heat exchange with vapor in the first evaporators 10, and is then introduced into the introduction portion 14 of the first evaporator 10 at the first stage.

[0027] The seawater guided from the introduction portion 14 into the heat transfer tubes 15 is heated by the heating source in the evaporation chamber 11a to be evaporated in the heat transfer tubes 15, and is then introduced into the vapor-liquid separation chamber 16a. The vapor (first vapor) introduced into the vapor-liquid separation chamber 16a is subjected to removal of its mixed liquid droplets through the demister 16b, and is then supplied, as a heating source, to the evaporation chamber 11a of the first evaporator 10 at the immediately subsequent stage via the connection tube 17. Meanwhile, the seawater separated from the vapor (first vapor) to be concentrated is introduced into the introduction portion 14 of the first evaporator 10 at the immediately subsequent stage, and passes through the insides of the heat transfer tubes 15. In this manner, the seawater is concentrated gradually at each stage of the plurality of first evaporators 10.

[0028] The vapor (first vapor) supplied to the first evaporator 10 at the last stage as a heating source is condensed by heat exchange with seawater passing through the heat transfer tubes 15 to become the distilled water (first distilled water), which is then introduced into the introduction portion 24 of the second evaporator 20 through an orifice to flow upward through the heat transfer tubes 25. The vapor (first vapor) generated in the first evaporator 10 at the last stage is supplied as a heating source to the evaporation chamber 21a of the second evaporator 20 via the connection tube 27, then is condensed by heat exchange with the distilled water (first distilled water) in the heat transfer tubes 25 to become distilled water (first distilled water), and is introduced into the introduction portion 24 of the second evaporator 20 through an orifice. Further, distilled water (first distilled water) obtained from the vapor (first vapor) supplied as a

heating source to the first evaporators 10 excluding those at the first stage and the last stage is supplied to the second evaporator 20 through the second supply portion 28.

[0029] In the second evaporator 20, the distilled water (first distilled water) of the first vapor generated in the first evaporator 10 is thus heated by the first vapor serving as a heating source to be evaporated again, thereby generating the second vapor. The vapor (second vapor) introduced into the vapor-liquid separation chamber 26a of the second evaporator 20 is subjected to removal of its mixed liquid droplets through the demister 26b, and is then introduced into the condensation chamber 31 of the condenser 30 and condensed by the seawater passing through the condensation tube 32 to become distilled water (second distilled water). The distilled water (second distilled water) generated in the condenser 30 is discharged through the second collection port 34 to the outside, and can be collected by operation of a pump 52. On the other hand, the distilled water (first distilled water) separated from the vapor (second vapor) in the second evaporator 20 is discharged through the first collection port 26c to the outside, and can be collected by operation of a pump 50. Vapor that is not condensed in the condensation chamber 31 is discharged through the vapor extraction port 33, then is sucked into a suction port of the ejector 40 along with seawater discharged from the water discharge port 16d of the first evaporator 10 at the last stage, and is supplied again toward the condensation tube 32 of the condenser 30.

[0030] According to the marine fresh water generator 1 of the present embodiment, the first distilled water can be collected from the first collection port 26c of the second evaporator 20, and the second distilled water having purity higher than that of the first distilled water can be collected from the second collection port 34 of the condenser 30. Thus, it is possible to efficiently produce water having purity required for a ship, without separately providing a pure water generator as in the conventional case.

[0031] The marine fresh water generator 1 of the present embodiment further includes a first circulation device 51 and a second circulation device 53. The first circulation device 51 returns the first distilled water to the first evaporator 10 when the purity of the first distilled water collected from the second evaporator 20 is not desired purity. The second circulation device 53 returns the second distilled water to the second evaporator 20 when the purity of the second distilled water collected from the condenser 30 is not desired purity.

[0032] The first circulation device 51 includes a sensor that detects the electrical conductivity of the first distilled water, and a switching valve that switches the flow path of the first distilled water between a collection side and a circulation side on the basis of the detection made by the sensor. While the first circulation device 51 supplies the first distilled water to the collection side when the detected purity of the first distilled water is the desired purity, the first circulation

device 51 returns the first distilled water to the circulation side when the detected purity of the first distilled water is not the desired purity. The first distilled water returned to the circulation side is returned to the first evaporator 10 through the first supply portion 18 to be reheated along with seawater in the first evaporator 10. The first supply portion 18 is preferably formed in the first evaporator 10 at the last stage as in the present embodiment. However, the first supply portion 18 may be formed in another one of the first evaporators 10.

[0033] The second circulation device 53 includes a sensor that detects the electrical conductivity of the second distilled water, and a switching valve that switches the flow path of the second distilled water between a collection side and a circulation side on the basis of the detection made by the sensor. While the second circulation device 53 supplies the second distilled water to the collection side when the detected purity of the second distilled water is the desired purity, the second circulation device 53 returns the second distilled water to the circulation side when the detected purity of the second distilled water is not the desired purity. The second distilled water returned to the circulation side is returned to the second evaporator 20 through the second supply portion 28 to be reheated along with the first distilled water in the second evaporator 20.

[0034] As described above, by providing the first circulation device 51 and the second circulation device 53, each of the purity of the first distilled water and the purity of the second distilled water to be collected can be maintained at its corresponding desired purity. Thus, it is possible to reliably produce water having purity required for a ship.

[0035] Although an embodiment of the present invention has been described in detail, specific aspects of the present invention are not limited to this embodiment. For example, the second evaporator 20 and the condenser 30 according to the embodiment described above are used for producing the second distilled water having high purity. However, the marine fresh water generator 1 can be configured such that, under a situation in which the high-purity distilled water is not required, the second evaporator 20 and the condenser 30 can produce the first distilled water.

[0036] For example, as illustrated in FIG. 2, a switching device 60 including a plurality of on-off valves 61 to 68 can be provided to allow the vapor generated in the second evaporator 20 of the marine fresh water generator 1 illustrated in FIG. 1 to be changed from the second vapor to the first vapor. In the relevant part of the marine fresh water generator illustrated in FIG. 2, the components similar to those in FIG. 1 are denoted by the same reference signs as those in FIG. 1 (the same applies to the following drawings).

[0037] In the configuration illustrated in FIG. 2, in a case where the second distilled water is produced in the condenser 30 by generating the second vapor in the second evaporator 20, the

on-off valves 61, 63, 65, 67 are controlled to be opened and the on-off valves 62, 64, 66, 68 are controlled to be closed. In contrast, in a case where the first distilled water is produced in the condenser 30 by generating the first vapor in the second evaporator 20, the on-off valves 62, 64, 66, 68 are controlled to be opened and the on-off valves 61, 63, 65, 67 are controlled to be closed. The first distilled water having passed through the on-off valve 64 is supplied to a third supply portion 35 formed in the condenser 30. The control of the switching device 60 in this manner enables the following production for each case described above. That is, in the former case, for example, 5 t/d of distilled water (first distilled water) at 10 ppm can be produced, and 5 t/d of pure water (second distilled water) can also be produced. In the latter case, for example, 15 t/d of distilled water (first distilled water) at 10 ppm can be produced. Thus, it is possible to flexibly respond to the needs for purity and an amount of production of water in a ship.

[0038] The first evaporators 10 are preferably provided in a plural manner, as in the embodiment described above, to be configured to have multiple effects. In this arrangement, by providing a conventional n-fold-effect fresh water generator including n first evaporators 10 with a second evaporator 20 in an additional manner, the configuration in appearance can be made similar to an (n+1)-fold-effect fresh water generator. Thus, it is possible to produce distilled water having high purity with a compact configuration. However, a single first evaporator 10 may be provided as in the marine fresh water generator 1 illustrated in FIG. 3.

[0039] In the marine fresh water generator 1 illustrated in FIG. 3, vapor (first vapor) generated in the first evaporator 10 is supplied as a heating source to the evaporation chamber 21a of the second evaporator 20 via the connection tube 27, then is condensed by heat exchange with distilled water (first distilled water) in the heat transfer tubes 25 to become distilled water (first distilled water), and is introduced into the introduction portion 24 of the second evaporator 20. The introduction portion 24 also receives introduction of part of distilled water (first distilled water) that has been separated from vapor (second vapor) in the second evaporator 20 and that has been then discharged through the first collection port 26c. The introduction portion 24 can further receive introduction of part of distilled water (second distilled water) that has been generated in the condenser 30 and that has been then discharged through the second collection port 34. The overflow water of the second evaporator 20 is discharged through an overflow port 29 to be sucked into the suction port of the ejector 40.

[0040] The marine fresh water generator 1 according to the embodiment described above is configured such that the seawater and the distilled water respectively passing through the insides of the heat transfer tubes 15, 25 are heated by the heating sources introduced to the outsides of the heat transfer tubes 15, 25, in the evaporation chambers 11a, 21a of the first evaporator 10 and the second evaporator 20. However, as in the marine fresh water generator 1 illustrated in FIG.

4, heaters 11c, 21c can be respectively provided in heating tanks 11b, 21b provided in the evaporation chambers 11a, 21a, to heat seawater and distilled water respectively supplied to the heating tanks 11b, 21b by using heat sources passing through the insides of the heaters 11c, 21c, and to evaporate the seawater and the distilled water. The seawater that is not evaporated in the first evaporator 10 is supplied to the heating tank 11b of the first evaporator 10 at the immediately subsequent stage via an overflow tank 11d. The first distilled water that is not evaporated in the second evaporator 20 can be collected via an overflow tank 21d. Other configurations are similar to those of the marine fresh water generator 1 illustrated in FIG. 1.

CLAIMS

1. A marine fresh water generator, comprising:
 - a first evaporator configured to heat seawater to generate first vapor;
 - a second evaporator configured to heat first distilled water obtained by condensing the first vapor to generate second vapor; and
 - a condenser configured to generate second distilled water obtained by condensing the second vapor,wherein the first distilled water and the second distilled water can be collected from the second evaporator and the condenser, respectively.
2. The marine fresh water generator according to claim 1,
 - wherein a plurality of the first evaporators is provided, and is configured to have multiple effects to allow the first vapor generated in at least one preceding one of the plurality of the first evaporators to be supplied as a heating source of at least one subsequent one of the plurality of the first evaporators, and
 - wherein the first distilled water includes distilled water obtained from the first vapor supplied as a heating source to a last one of the plurality of the first evaporators and distilled water obtained from the first vapor supplied as a heating source to the second evaporator.
3. The marine fresh water generator according to claim 1, further comprising a switching device capable of switching a heating target of the second evaporator to allow vapor generated in the second evaporator to be changed from the second vapor to the first vapor.
4. The marine fresh water generator according to claim 1, further comprising a first circulation device configured to detect purity of the first distilled water collected from the second evaporator, the first circulation device being configured to return the first distilled water to the first evaporator to cause the first distilled water to be reheated along with the seawater when the purity that has been detected is not desired purity.
5. The marine fresh water generator according to claim 1, further comprising a second circulation device configured to detect purity of the second distilled water collected from the condenser, the second circulation device being configured to return the second distilled water to the second evaporator to cause the second distilled water to be reheated along with the first distilled water when the purity that has been detected is not desired purity.