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(54) METHOD AND APPARATUS FOR THE DESALINATION OF WATER

- (71) We, KURITA WATER INDUSTRIES LTD. a corporation organised and existing under the laws of Japan of No. 1, 3-chome, Koraibashi, Higashi-ku, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- 10 This invention relates to a method and apparatus for the desalination of water. More particularly, this invention relates to method and a apparatus for desalinating water by bringing hot water into contact with a gas flow under substantially atmospheric pressure to generate water vapor the temperature of which is not much lower than that of said hot water and condensing said water vapor into water.
- 20 In conventional types of water desalination apparatus for effecting flash evaporation under reduced pressure, the evaporator must be designed as a pressure vessel, and it is further necessary to use a vacuum pump for reducing the pressure and to use a low net positive suction head pump of high efficiency for withdrawing the brine used or the fresh water produced. As a result the cost of the equipment and the water-making cost both become extremely high. This tendency is strikingly apparent in modern water desalination apparatus of the multi-stage type wherein to raise the water-making efficiency, the temperature of the raw material water to be fed into the evaporator in the first stage is sometimes elevated to 150°C and, accordingly, the pressure reaches 4.8 kg/cm². In the final stage, the temperature is lowered as much as possible to make the degree of vacuum 720 mmHg (35°C). Further, the flash-evaporation type is defective in that, because of flash evaporation being effected under reduced pressure, the steam temperature becomes strikingly lower than the original hot-water temperature, and, therefore, it becomes necessary to use a cooling water of a lower temperature in condensing the steam. For example, in steam driven electric generation plants, engines for ships, or brine evaporating apparatus, a large amount of cooling water is required and brine is used as such cooling water. In this case, the brine used is usually warmed to about 40°C, so, if it is flash-evaporated under reduced pressure, the temperature of the steam generated becomes close to that of fresh brine which is not used for cooling, and, accordingly, the steam generated can no longer be condensed with brine.
- 60 According to the present invention, there is provided a method for the desalination of water, which method comprises the steps of bringing a gas flow under substantially atmospheric pressure into contact with heated water to evaporate a first part of said water into vapour, and collecting a second part of said water; condensing said vapour into desalinated water by passing said vapour through a condenser and removing said desalinated water from said condenser; cooling said condenser with water, a part of said cooling water leaving the condenser being mixed with said second part of said water after said condensation; and heating said water mixture to provide said heated water for said contact with said gas flow, said mixture having a predetermined proportion of said second part of water relative to said condenser cooling water.
- 80 The invention also provides apparatus for use in carrying out the method which apparatus comprises a gas-liquid contacting device for contacting the gas flow with the heated water, said device including means for collecting said second part of said water; a water cooled condenser for condensing said vapour into desalinated water for disposal from the condenser; means for connecting said condenser cooling water to said second part of said water for mixture therewith in a predetermined proportion after said condensation; and means for heating said water mixture to provide said heated water.

This apparatus differs from the system of flash evaporation under saturation temperature and saturation pressure in that there is little adhesion of scale or depositing of salt and, further, the efficiency of operation is not lowered even if the gas-liquid contacting device is not completely sealed.

Water vapor evaporated from brine which is approximately 40°C after having been used to cool an engine can be easily be converted to fresh water by condensing in heat exchange with the brine that is being used as the coolant for the engine since the temperature of the water vapor is not much below 40°.

The waste water from thermal electric plants, ship engines, or sea water evaporators, is used as the warm water which is evaporated to produce fresh water and thus, with the exception of the power used to drive the fan, no external power source is necessary.

As a result of this invention, the apparatus itself is light and small in size as the evaporator serves only to bring the gas into contact with water and thus the conventional cooling tower, filling tower, and spray tower can be used with only slight modification.

The invention will now be described by way of example only, with reference to the drawings in which:—

Figure 1 is a schematic view of apparatus for producing fresh water from the water used as the cooling water for a multistage flash evaporation-type water desalination apparatus, and can be used to carry out the method of the invention.

Fig. 2 is a schematic view of apparatus for producing fresh water from the water used for cooling a Diesel engine and can be used to carry out the method of the invention.

Fig. 3 is a schematic view of apparatus used to carry out the method of the invention.

Referring to Fig. 1, 1 is a gas-liquid contacting device, 2 is a water vapor condenser, 3 is a passage through which gas containing water vapor travels from gas-liquid contacting device 1 to water vapor condenser 2, 4 is a supply pipe for the warmed raw feed water, and 5 is a cooling pipe through which the cooling water passes. In this embodiment, the raw material water is fed into supply pipe 4 after being warmed by a multi-stage flash evaporation-type water desalination apparatus A; that is, fresh water is made from the brine used as the cooling water for evaporators of said apparatus A.

Gas-liquid contacting device 1 is shown with a packed tower, at the middle of which filling material 6 is disposed, and above filling material 6 are disposed spray nozzle 7, droplet eliminator 8 and fan 9 in the order mentioned. One end of passage 3 is connected to the upper end of gas-liquid contacting device 1, and supply pipe 4 is connected to spray nozzle 7.

In device 1, gas inlet 10 opens at a position below filling material 6, and drain pipe 11 is connected to the bottom of device 1.

Drain pipe 12 is connected to water vapor condenser 2, and cooling pipe 5 is disposed so as to pass through water vapor condenser 2.

The feed water drawn up by pump 14 through water intake pipe 13 is fed into cooling pipe 5. 15 is a drain pipe, 16 is a drain tank, and 17 is a drain pipe for the cooling water which has passed through cooling pipe 5 in water vapor condenser 2.

The multi-stage flash evaporation-type water making desalination apparatus A has a first group of evaporators 18a to 18n and a second group of evaporators 19a to 19n, the evaporators of each group being connected with one another at the bottom and said evaporator groups being provided with condensers 18a' to 18n' and 19a' to 19n' respectively. Cooling pipe 5 branches off from drain pipe 17 and connects to cooling pipe 20 which passes through the condensers of the second evaporator group from 19n' to 19a', cooling pipe 20 branching off and connecting to supply pipe 4 and to water supply pipe 21 of apparatus A. Water supply pipe 21 is connected to circulating pipe 22 which, starting from the last evaporator 19n of the second evaporator group, passes through pump 23 and then through the cooling pipes of the condenser of the first evaporator group from 18n' to 18a'.

The water in circulating pipe 22, which passes through condensers 18n'—18a', further passes through heater 24 and is connected to the first evaporator 18a of the first evaporator group. Drain pipe 25 connected to the last evaporator 19n of the second evaporator group communicates with supply pipe 4 through pump 26. 27 is a drain pipe connected to condenser 19n' mounted to the last evaporator 19n of the second evaporator group, the drain being pumped through said drain pipe 27 into drain tank 16 by pump 28. 29 is a steam pipe connected to heater 24 which heats the water passing through circulating pipe 22. 30 is an ejector connected to condenser 19n' to reduce the pressure of the evaporators in the order of 18a—18n and 19a—19n.

Starting fan 9 draws air into the lower part of gas-liquid contacting device 1 through gas inlet 10 and sucks it upward while, on the other hand, the water warmed while passing through the apparatus A is sprayed out of supply pipe 4 over the filling material 6 by spray nozzle 7, with the result that the air and the hot water are brought into contact in said filling material.

In consequence, the air is warmed to a temperature close to that of the hot water supplied and, at the same time, a part of the hot water evaporates to generate water vapor.

The hot water is cooled by the latent heat of said water vapor but, because of the water vapor contained in the gas current, the humidity increases and simultaneously, the temperature becomes close to that of the hot water. The water vapor-containing gas current passes through eliminator 8, whereby the water drops are removed, then enters water vapor condenser 2 through passage 3 and is cooled by the water passing through cooling pipe 5. Here the water vapor is condensed into water, which is then collected as fresh water through drain pipe 15 into drain tank 16.

Most of the feed water brine drawn up by pump 14 is discharged from drain pipe 17 after passing through cooling pipe 5 to condense the water vapor but the remainder, entering cooling pipe 20, condenses the steam in condensers 19n'—19a' and is warmed. A part thereof then enters supply pipe 4, is sprayed over filling material 6 in gas-liquid contacting device 1, and is collected as fresh water in the way mentioned above. The remaining part of the brine which did not enter supply pipe 4 passes through water supply pipe 21 into circulating pipe 22, is then flash-evaporated by apparatus A, is condensed, and is collected as fresh water through drain pipe 27. And the brine which was not evaporated even in the last evaporator 19n comes in part as circulating water into circulating pipe 22, and the remainder passes through drain pipe 25 into supply pipe 4 and is evaporated.

Fig. 2 shows apparatus wherein fresh water is produced from the cooling water in the jacket of the Diesel engine of a ship from which it may be understood that this apparatus is advantageously applicable to ships.

The brine drawn up by brine pump 31 through water intake pipe 32 and fed into the packet of Diesel engine 33 cools the engine and is thereby warmed by about 6—15°C.

The brine which is usually discharged into the sea is, according to this invention, introduced by supply pipe 34 into gas-liquid contacting device 35, wherein a part of the brine is sprayed by spray nozzle 36 over filling material 37, the remainder being passed overboard through drain pipe 38. Gas-liquid contacting device 35 is shown with a filling tower, gas being blown into device 35 from the bottom by fan 39. Accordingly, the gas and the brine sprayed come in contact with each other in device 35, wherein, in the same way as in the embodiment shown in Fig. 1, a part of the brine is evaporated and mixed in the gas stream. This gas stream passes through eliminator 40, whereby the water drops are removed, and is sent through passage 41 into water vapor condenser 42.

The brine drawn up by a brine pump 44 flows through cooling pipe 43 which passes through water vapor condenser 42 to condense the water vapor contained in the gas

in condenser 42. The condensed water vapor is separated from the gas by eliminator 46 and collected as fresh water through drain pipe 45 into drain tank 47. The gas which passed through the eliminator 46 is blown into gas-liquid contacting device 35 from the bottom through duct 48 by a fan 39.

The apparatus shown in Fig. 3 is a modification of the apparatus shown in Fig. 2. Gas-liquid contacting device 49 is provided at the middle with filling material 50, above which spray nozzle 51 is disposed to spray the brine which has passed through heater 52. Heater 52 may be a Diesel engine, a steam driven electric generation plant, or a brine evaporating apparatus. Gas is blown into gas-liquid contacting device 49 from the bottom by fan 53 and passes upward through filling material 50. Accordingly, the brine sprayed from the top and the gas steam blown upwardly from the bottom contact each other in filling material 50 to cause evaporation. The water vapor-containing gas stream passes through eliminators 54 and 54', whereby the water drops are separated, and then, passing through passage 55, enters water vapor condenser 56 from the top and is cooled by the raw water passing through cooling pipe 57 in said water vapor condenser. Thus the water vapor contained in said gas stream is condensed and collected as fresh water through drain pipe 65 at the bottom of said water vapor condenser 56. Also, the brine deprived of its latent heat in filling material 50 collects at the bottom of gas-liquid contact device 49. Fan 53 is provided at a position lower than cooling pipe 57 in water vapor condenser 56. Said fan blows the gas deprived of moisture in condenser 56 into gas-liquid contacting device 49 from the bottom through eliminator 58. Accordingly, the gas circulates through gas-liquid contacting device 49 and water vapor condenser 56. The brine collected at the bottom of gas-liquid contacting device 49 is sent through pump 59 and check valve 60 to heater 52 after being mixed in a predetermined proportion with the raw water; used in the condenser 56. This mixture is sprayed over filling material 50. Ball tape 61 detects the water level of the brine collected, and while controlling the flow of the raw water which has passed through cooling pipe 57 in water vapor condenser 56, allows a part thereof to flow into the bottom of gas-liquid contacting device 49, the greater part of said raw water being discharged. A flow meter 62, which measures the flow rate to heater 52, adjusts valve 63 to discharge the brine-containing raw material water to be sent through check valve 60 to heater 52.

The concentration of the water to be sprayed over the filling material 50 may be kept constant by means other than that of the above embodiment. For example, when the flow rate of the cooling water to be dis-

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charged from cooling pipe 57 in water vapor condenser 56 is constant, it suffices to supply said cooling water into the system at an optional position thereof between the outside of the bottom of gas-liquid contacting device 49 and spray nozzle 51; detect the water level of the brine by ball tap 64 and adjust the degree of opening of valve 3. Thus, in this invention, it is also possible to make fresh water by repeatedly supplying brine to water warmed while condensing the water vapor.

It will be understood that the brine which collects in the bottom of the gas-liquid contacting device as shown in Figures 1 and 2 may be added to the raw feed water and the mixed water of fixed concentration, or predetermined proportion, is brought into contact with the air in the gas-liquid contacting device.

20 WHAT WE CLAIM IS:—

1. A method for the desalination of water, which method comprises the steps of bringing a gas flow under substantially atmospheric pressure into contact with heated water to evaporate a first part of said water into vapour, and collecting a second part of said water; condensing said vapour into desalinated water by passing said vapour through a condenser and removing said desalinated water from said condenser; cooling said condenser with water, a part of said cooling water leaving the condenser being mixed with said second part of said water after said condensation; and heating said water mixture

to provide said heated water for said contact with said gas flow, said mixture having a predetermined proportion of said second part of water relative to said condenser cooling water.

2. Apparatus for use in carrying out the method as claimed in claim 1 which apparatus comprises a gas-liquid contacting device for contacting the gas flow with the heated water, said device including means for collecting said second part of said water; a water cooled condenser for condensing said vapour into desalinated water for disposal from the condenser; means for connecting said condenser cooling water to said second part of said water for mixture therewith in a predetermined proportion after said condensation; and means for heating said water mixture to provide said heated water.

3. Apparatus as claimed in claim 2 wherein the heating means are an evaporating apparatus, a steam driven electricity generation plant or a shipborne Diesel engine.

4. Apparatus for the desalination of water substantially as herein described with reference to, and as shown in, Figure 3 of the accompanying drawings.

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