

Water treatment method and apparatus

Technical field

[0001]

The present invention relates to a method and an apparatus for reusing backwash wastewater, washing effluent, circulating water, concentrated water or the like of a membrane separation apparatus, and more particularly to a water treatment method and an apparatus suitable for recovering cooling tower blow water.

BACKGROUND ART

[0002]

Scale failures occur on heat transfer surfaces and piping contacting water in cooling water systems and boiler water systems. In particular, when performing highly concentrated operation with less cooling water discharged outside the system (blow down) from the standpoint of resource saving and energy conservation, dissolved salts are concentrated and a heat transfer surface tends to corrode whereby producing soluble salts and scales. When scale sticks to a surface of an equipment or the like, serious troubles such as a drop in thermal efficiency and clogging of piping are caused in an operation of a boiler and a heat exchanger. In recent years, water has been used efficiently as much as possible for the purpose of water saving and energy saving. However, in the case of further highly concentrated operation, there is a limit to prevent scale deposition.

[0003]

It is known that blowdown water from a cooling water system is passed through an MF membrane or a UF membrane to remove turbidity in the

blowing water, and then treated by an RO membrane to remove ions, organic matter and the like and is returned to the cooling tower (Patent Documents 1 , 2).

[0004]

[Patent Document 1] JP 2002-18437 A

[Patent Document 2] JP 2003-1255 A

[0005]

In a method of recovering water using an MF membrane, a UF membrane, and an RO membrane, it is necessary to wash the membrane periodically or irregularly. In Patent Documents 1 and 2, since backwash effluent is discharged outside the system, the water recovery rate is low. Also, when backwashing water, circulating water, concentrated water, washing effluent and the like are discharged outside the system, wastewater treatment may be required depending on the quality of the water.

SUMMARY OF THE INVENTION

[0006]

It is an object of the present invention to provide a method and an apparatus for treating backwash effluent, washing effluent, concentrated water, or circulating water of a membrane separation apparatus to use the treated water as cooling water for a cooling tower.

[0007]

The water treatment method of the present invention comprises supplying a part or the whole of water discharged from a membrane separation apparatus to a cooling tower, the water being at least one of backwash drainage, washing drainage, circulating water and

condensed water of the membrane separation apparatus.

[0008]

The water treatment apparatus of the present invention is a water treatment apparatus having a membrane separation apparatus, wherein the water treatment apparatus comprises a supply device for supplying a part or the whole of water discharged from the membrane separation apparatus to a cooling tower, the discharged water being at least one of backwash drainage, washing drainage, circulating water and concentrated water of the membrane separation apparatus.

[0009]

The membrane separation apparatus preferably includes a pretreatment membrane device and a reverse osmosis membrane device, and the pretreatment device preferably has at least a microfiltration membrane or an ultrafiltration membrane.

[0010]

In one aspect of the present invention, the cooling tower comprises a filtration device for circulating filtration of at least a portion of the cooling water.

[0011]

In the present invention, it is preferable to feed the water discharged from the membrane separation device into the cooling tower after filtration treatment. In this case, it is preferable that the filtration treatment is performed by a filtration device for circulating and filtering at least a part of the cooling water provided in the cooling tower.

[0012]

In one embodiment of the present invention, a water supply pipe is

connected to the cooling tower for feeding water from the cooling tower to a filtering device for circulating and filtering at least a part of the cooling water, and the water discharged from the membrane separation apparatus is supplied to the water supply pipe or the vicinity of the pipe connecting portion in the cooling tower.

[0013]

In one embodiment of the present invention, the water discharged from the membrane separation apparatus is temporarily stored in a tank and then supplied to the cooling tower.

[0014]

In one embodiment of the present invention, blowing water of the cooling tower is supplied to the membrane separation apparatus.

EFFECT OF THE INVENTION

[0015]

In the water treatment method and apparatus of the present invention, water recovery rate is improved, since at least one of the backwash drainage, the washing drainage, and the concentrated water of the membrane separation apparatus installed in various water treatment lines is supplied to the cooling tower and used as cooling water. Particularly, the cooling tower blow water is treated with a membrane separation apparatus and reused as cooling water, and at least one of backwashing drainage washing water, washing drainage, circulating water and concentrated water of this membrane separation apparatus is used as cooling water, the water recovery rate of the cooling tower can be increased.

[0016]

In one embodiment of the present invention, blow water is filtered with an MF membrane or a UF membrane, and then treated with an RO membrane to deionize and remove organic matter, and the RO treated water is used as cooling water for a cooling tower. In addition, the backwashing drainage of the MF membrane or the UF membrane, the circulating water, the concentrated water, or the washing drainage of the RO membrane is filtered and then supplied to the cooling tower. Existing equipment can be used by performing this filtration process with a filtration device for circulating filtration of at least a part of the cooling water installed in the cooling tower system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a flowchart showing a water treatment method and apparatus according to an embodiment.

FIG. 2 is a flowchart showing a water treatment method and apparatus according to an embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0018]

Hereinafter, embodiments will be described with reference to the drawings. FIG. 1 shows an example of a cooling tower system to which the method and apparatus of the present invention are applied.

[0019]

The cooling tower 1 of the cooling tower system contacts air introduced from a louver 1c, and cooling water sprinkled from a water sprinkling pipe 1a flows down a packed layer 1b and is stored in a cooling pit 1d. The air containing steam is discharged into the atmosphere by a fan 1e.

The cold water in the pit 1d of the cooling tower 1 is supplied to a heat exchanger 4 via a pump 2 and a pipe 3, and the water from the heat exchanger 4 is returned to the water pipe 1a of the cooling tower 1 via a pipe 5.

[0020]

A part of the water of the pit 1d is supplied to a side filter 14 via a water supply side circulation pipe 11, a pump 12, and a valve 13. The filtered water is returned to the pit 1d via return side circulation piping 15, 17 and a valve 16. The side filter 14 may be a floating filter using a floating filter material, a filtration device such as a sand filter, or the like. Backwashing air can be introduced into the pipe 15 via an air pump 19 and a valve 18. To the primary side of the side filter 14 is connected an exhaust pipe 14 of backwash drainage effluent having a valve 14a.

[0021]

When the filtration process is performed by the side filter 14, the valves 13, 16 are opened and the valves 14a, 18 are closed. When back flushing the side filter 14, the valves 13, 16 are closed, the valves 14a, 18 are opened, the air is supplied from the air pump 19 to the side filter 14, and the backwash effluent is discharged via the pipe 14b .

[0022]

In the cooling tower 1, makeup water is supplied from a make-up water line 8 so that the water level in the pit 1d always becomes a predetermined level by a ball tap valve device 7 (or a water supply valve device with a level sensor).

[0023]

An electric conductivity meter for measuring the electric conductivity of

the cooling water in the pit 1d is provided. When the electric conductivity detected by the electric conductivity meter becomes a predetermined value or more, the blow valve 21 is opened, and a part of the cooling water whose salt concentration has increased is discharged as blow water through the pipe 22. In this embodiment, the blowing water is sent to a water treatment device 25 via a pump 23 and a pipe 24. If water can be fed by gravity, the pump 23 becomes unnecessary. The configuration of the water treatment apparatus 25 will be described later.

[0024]

In the cooling tower 1, a part of the circulating water is evaporated in order to remove the heat of the process, and the water is concentrated. Since the concentrated cooling water contributes to scaling and slime generation whereby the heat exchanging efficiency of the heat exchanger is adversely affected, chemicals such as a dispersant and slime prevention agent for preventing them are added.

[0025]

Examples of the dispersant include inorganic polyphosphoric acids such as sodium hexametaphosphate and sodium tripolyphosphate, phosphonic acids such as hydroxyethylidenediphosphonic acid and phosphonobutane tricarboxylic acid, carboxyl group-containing materials such as maleic acid, acrylic acid, itaconic acid, etc. Examples of the dispersant also include a copolymer of a combination of vinyl monomer having a sulfonic acid group such as vinylsulfonic acid, allylsulfonic acid, and 2-methacrylamido-2-methylpropanesulfonic acid and a nonionic vinyl monomers such as acrylamide. However, materials

other than those listed here. The dispersant may contain a terpolymer including a third component. For example, N-tert-butyl acrylamide or the like is used as the third component.

[0026]

Among them, the dispersant is most preferably a copolymer of HAPS (3-allyloxy-2-hydroxy-1-propanesulfonic acid) and acrylic acid and / or methacrylic acid, or a copolymer of AMPS (2-acrylamide-2-methylpropanesulfonic acid) and acrylic acid and / or methacrylic acid.

[0027]

The molecular weight of the dispersant is preferably 1,000 or more and 30,000 or less. When the molecular weight is less than 1,000, sufficient dispersion effect can not be obtained, and if it exceeds 30,000, there is a possibility of being removed by the pretreatment membrane. The present invention is also characterized in that the cooling water chemical contained in the cooling tower blow water is reused as a chemical for reverse osmosis membrane, and the above-mentioned dispersant, slime prevention agent or the like described later is effectively utilized.

[0028]

Examples of slime prevention agents include hypochlorite such as sodium hypochlorite (NaClO); chlorine agent such as chlorine gas, chloramine and chlorinated isocyanurate; combined chlorine agent (stabilized chlorine agent) produced by reacting chlorine such as monochlorosulfamic acid with amidosulfuric acid, or a compound having amidosulfuric acid group; a bromine agent such as

dibromohydantoin; a combined bromine agent (a stabilized bromine agent) produced by reacting bromine such as monobutylsulfamic acid and amidosulfuric acid or a compound having amidosulfuric acid group; an organic chemical such as DBNPA (dibromonitrilopropionic acid), or MIT (methylothiazolone), etc.

[0029]

Examples of the nitrogen compound to which free chlorine or free bromine is bonded in the combined chlorine agent and combined bromine agent include ammonia or a compound thereof, melamine, urea, acetamide, sulfamide, cyclosulphamic acid, sulfamic acid, toluenesulfonamide, succinimide, Phthalic acid imide, isocyanuric acid, N-chlorotoluenesulfonamide, uric acid, saccharin or salts thereof. The combined chlorine agent used in the present invention is one in which free chlorine is bonded to these nitrogen compounds. Examples of such a combined chlorine agent include chloramine, a combined chlorine agent composed of a chlorine type oxidizing agent and a sulfamic acid compound, chloramine-T (sodium salt of N-chloro-4-methylbenzenesulfonamide), chloramine-B (sodium salt of N-chloro-benzenesulfonamide), sodium salt of N-chloro-para nitrobenzenesulfonamide, trichloromelamine, sodium or potassium salt of mono- or di-chloromelamine, trichloro-isocyanurate, mono- or sodium or potassium salt of di-chloroisocyanuric acid, sodium or potassium salt of mono- or di-chlorosulfamic acid, such as monochlorohydantoin, 1,3-dichlorohydantoin, 5,5-alkyl derivatives such as 5,5-dimethylhydantoin. The combined bromine agent is also the same except that the chlorine portion is replaced by bromine.

[0030]

A chemical for changing the pH may be hydrochloric acid, sulfuric acid, nitric acid, sodium hypochlorite, sodium hydroxide, citric acid, oxalic acid or the like. There is no limit to the material.

[0031]

One or more kinds of chemicals are suitably used from the above. It is preferable to measure the concentration of slime inhibitor in the cooling tower and to control the injection amount. It is preferable to measure the pH of the cooling tower and to control it within a certain range.

[0032]

The water treatment device 25 for treating the blow water will be described below.

[0033]

After removing of coarse turbidity and foreign matters by a filter 30 such as a strainer, the blow water from a cooling tower is introduced into a tank 31. A slime prevention agent or a pH adjusting agent such as sulfuric acid is added to the tank 31, and then the water is subjected to a turbidity-removing process by a pretreatment membrane device 33. The water that has not permeated through a membrane 33m is introduced into the water supply side circulation pipe 11 via a pipe 34. The water that has not permeated may be returned directly into a pit 1d (cooling tower lower water tank), and may be returned to the tank 31. The permeated water of the membrane 33m is supplied to a RO membrane device 38 via a valve 35, a tank 36, and a pipe 37, and the deionization process is performed. The deionized treated water is returned to the cooling tower 1 via a pipe 39. The RO-treated water

may be returned to the make-up water line 8 or may be returned to the circulation pipes 11, 15, 17 etc. for the side filter 10.

[0034]

The brine of an RO membrane device 38 is preferably discharged via a valve 43 and a pipe 45.

[0035]

The RO membrane device 38 is intermittently flushed for cleaning or is subjected to chemical cleaning using alkali or acid. Drainage of the cleaning is also recovered via a pipe 42.

[0036]

Although it is possible to operate without a filter 30 such as the above-mentioned strainer, it is preferable to install it because there is a possibility that the pretreatment membrane device 33 may be broken. An automatic strainer that performs a cleaning process automatically is preferably used. There are no particular restrictions on the shape of the strainer, and any shape such as Y-type, bucket type can be used. The opening diameter of the strainer is preferably 100 to 500 μm . If the diameter less than 100 μm , the strainer tends to be clogged severely. When it exceeds 500 μm , there is a tendency that the possibility of coarse turbidity and foreign matter transmitted through the strainer damaging the pretreated membrane tends to be high. A filter such as a thread wound filter, a pleated filter or the like may be used instead of a strainer, but a strainer is more preferable in terms of exchange frequency and washability.

[0037]

The pretreatment membrane device 33 is for removing turbidity and

colloidal components in water that cause membrane contamination of the RO membrane device 38, and it is possible to use an MF membrane or a UF membrane. The membrane type is not particularly limited, and a membrane filtration device such as a hollow fiber type or a spiral type can be adopted. Also, there is no limitation on the filtration method, and any method of internal pressure filtration, external pressure filtration, cross flow filtration, whole volume filtration can be applied. The fraction molecular weight of the MF membrane and the UF membrane is preferably 30,000 or more. If it is less than 30,000, the dispersant may be removed. The upper limit of the fractional molecular weight is not particularly limited, but if it is 1,000,000 or less, polymeric polysaccharides and the like which can cause blockage of the RO membrane in cooling water can be removed, which is preferable. A water injection step or a circulation step for filling a housing with water, is performed at the beginning of operation of the pretreatment membrane apparatus and during an air removal step of the backwashing. The water (circulating water) discharged at this time is also returned to the water supply side circulation pipe 11, or the pit 1d directly through the pipe 34.

[0038]

As the slime preventing agent and the pH adjusting agent which can be used in the pretreatment membrane device 33 are the same as those used in the cooling tower can be used. By using the same kind, the agent can be effectively used even in the cooling tower. In the case where free chlorine or free bromine is used in the pretreatment membrane device 33, it reacts with the combined chlorine agent

(stabilizer), in the cooling tower, so that it is possible to reduce the amount of free chlorine being originally required to be added in the cooling tower.

[0039]

The pretreatment membrane device 33 is subjected regularly or irregularly to a backwashing treatment, and turbidity components and the like accumulated in the membrane 33m are discharged to the outside of the system. Backwashing frequency is generally about once every 10 to 60 minutes, but not limited to this. It is possible to improve recovery effect of the backwashing by adding hypochlorous acid and salts thereof, hypobromous acid and salts thereof, disinfectants such as organochlorine type bacteriocides, combined chlorine type bacteriocides, combined bromine type bacteriocides, slime control agents during backwashing or by changing the pH of the backwashing.

[0040]

In order to carry out this backwashing, in this embodiment, membrane permeated water in the tank 36 is utilized. That is, when the membrane 33m is backwashed, valves 32 and 35 are closed, valves 52 and 54 are opened, a pump 50 is operated, and the water in the tank 36 is supplied to the secondary side of the membrane 33m via pipes 51 and 53. At this time, chemicals such as NaClO or the like may be added to the pipe 53 to perform chemical cleaning. The backwash effluent is supplied from the pipe 34 to the pipe 11 (suction side of the pump 12). A air backwashing may be performed instead of the water backwashing. Also in this case, the backwash effluent is recovered via the pipe 34. It is also possible to perform immersion washing by adding a chemical such as

NaClO to the primary side of the membrane together with backwashing. The washing effluent at this time is also returned to the water supply side circulation pipe 11 or the pit 1d via the pipe 34.

[0041]

The type of the RO membrane 38m of the RO membrane device 38 is not particularly limited and is appropriately determined by the quality of the circulating cooling water to be treated (the raw water quality supplied to the circulating cooling water system or the concentration ratio in the circulating cooling water system). The desalination ratio of the RO membrane 38m is preferably 80% or more, particularly preferably 85% or more. When the desalting ratio is lower than this, the deionization efficiency is poor and it becomes difficult to obtain treated water (permeated water) of good quality. As the RO membrane 38m, any material such as a polyamide composite membrane and a cellulose acetate membrane can be used, but from the viewpoint of removal rate, a polyamide composite membrane is preferably used. The shape of the RO membrane 38m is not particularly limited, and any of hollow fiber type and spiral type can be used.

[0042]

It is preferable to add a slime inhibiting agent to the feed water of the RO membrane device 38. In the case of a polyamide composite membrane, a combined chlorine agent, a combined bromine agent and an organic agent are suitably used as slime inhibitor. The above-mentioned chlorine agent and bromine agent are undesirable because they may cause film deterioration. This step can be made unnecessary by sharing cooling water chemicals, dispersant or slime

inhibiting agent. In the present embodiment, the pH adjusting agent is added in the tank 31. However, depending on the kind of the dispersant, there is a possibility that the polymer may block the pretreatment membrane. Therefore, it is preferable to add the pH adjusting agent (for example, sulfuric acid) to the RO feed water instead of adding it at the preceding stage of the pretreatment membrane device.

[0043]

By returning backwash effluent or concentrated water to the pipe 11 as described above, the side filter 14 can remove the turbid components in the backwashing wastewater or the concentrated water, thereby preventing the concentration and concentration rise of the turbidity in the cooling water system. In the case where the side filter 14 is not provided, a separate filtering device may be provided in the return line.

[0044]

It is preferable that the ratio of the total amount of water per hour of the backwash effluent, circulating water, washing effluent, and concentrated water to be returned to the cooling tower to the amount of water held in the cooling water treatment system is 1: 100 or more. That is, the amount of water retained in the cooling tower when returning the backwash effluent and the concentrated water is preferably equal to or more than 100 times the return amount. As long as it has a water amount of 100 times or more, the increase in concentration is suppressed low at the time of return and it can be set to a level at which no problem occurs. In the case of returning the backwash effluent or the concentrated water, a pH measuring device, a pH adjusting device, a chlorine measuring device, and a chlorine

adjusting device may be installed in order to prevent fluctuation of the water quality of the cooling water.

[0045]

In the present embodiment, the tank is provided in the water treatment apparatus for treating the blowing water, but the tank may be deleted. In one embodiment of the present invention, as shown in FIG. 2, the backwash effluent, the concentrated water, the circulating water, and the wash drainage are temporarily stored in a water tank 55 and are returned to the pipe 11 or the cooling tower quantitatively via a pump 56 and a pipe 57 in order to equalize the inflow load.

[0046]

The water quality of the backwash waste water, circulating water, washing waste water or concentrated water may be detected with a sensor, and recovery may not be performed when the concentration is higher than the specified concentration.

[0047]

As described above, in this embodiment, the backwash waste water from the pretreatment membrane device 33, the circulating water, the concentrated water, and the chemical washing waste water are recovered. Flushing wastewater from the RO membrane device 38, chemical liquid washing water and circulating water are recovered.

[0048]

Although the pretreatment membrane device 33 and the RO membrane device 38 are used in the above description, other membranes and a filtration device may be used, and all of the washing waste water, concentrated water and the like are recovered. The washing waste

water may be supplied to the cooling tower via a line branching from the drain line or may be directly supplied to the cooling tower via the supply line. The concentrated water may be branched from the circulation line and supplied to the cooling tower, or all of the concentrated water may be supplied to the cooling tower.

[0049]

In the above embodiment, concentrated water, backwash effluent and the like are returned to the circulating water supply piping 11 for the side filter 14, but they may be returned to other places. They may be returned directly to the pit 1d, for example, in the vicinity of the connecting portion of the pipe 11. By arranging the return destination in the vicinity of the connecting portion of the pipe 11 of the pit 1 d, that is, in the vicinity of the suction port, when water containing turbidity enters the pit, it is immediately sent to the side filter 14 via the pipe 11 and treated. Depending on water quality, it may be returned via the pipe 3.

[0050]

In the above embodiment, the recovery water treatment apparatus includes the filter 30, the pretreatment membrane device 33 such as a UF membrane device, and the RO membrane device 38, but it is also possible to use a filter, a UF membrane, an MF membrane, a nanofiltration membrane and an RO membrane, or a combination of any two or more thereof.

[0051]

In the present invention, it is preferable that the turbidity of the backwash effluent, the circulating water, the washing effluent, and the

concentrated water is less than 1000 degrees. The turbidity of the backwash effluent instantaneously becomes about 300 degrees at maximum, but it decreases to 1 degree or less by filtration. The pH of the backwash effluent, the circulating concentrated water and the washing effluent is preferably 2 to 12.

[0052]

In the above embodiment, the blowdown water of the cooling tower is recovered by treating it with the membrane device. However, washing effluent etc. of membrane treatment equipment installed in factories, plants, etc., for treating water and waste water may be treated in the water treatment device 25 and used as cooling water for the cooling tower 1. Since the blowdown water of the cooling tower includes the same turbid components as the washing wastewater, there is an advantage that it is easy to apply.

[0053]

In the above embodiment, water is sent to the water treatment apparatus via the blow piping 22, but it can also be sent from the position of the feed pipe 3 and the return pipe 5 to the heat exchanger by utilizing the pressure of the pump 2.

Examples

[0054]

[Example 1]

Blow water of a cooling tower was recovered. The cooling tower used Chiba city water as raw water, and had $5,000 \text{ m}^3 / \text{h}$ of circulating water and a holding water volume of $1,000 \text{ m}^3 / \text{h}$. A concentration ratio thereof was 3.5 times.

[0055]

A copolymer of acrylic acid and AMPS (molar ratio 70:30) and a dispersant having an average weight molecular weight of 10,000 were used for cooling water dispersant treatment. The dispersant holding concentration in the initial of the system at the starting was 3 mg / L. A mixture of alkali, sulfamic acid, and hypochlorous acid described in WO11 / 125762 was used as slime inhibitor. The slime inhibitor was added so that the initial combined chlorine concentration in the system was 1.0 mg / L. In the cooling tower, a light filter made by Kurita Water Industries Ltd. was installed as a side filter, and filtration was carried out at 150 m³ / h to remove a predetermined amount of turbidity in the system.

[0056]

The recovery was conducted by a strainer, an MF apparatus, and an RO membrane apparatus as in the water treatment apparatus 25 of FIG. 1. The whole amount of blow water of 20 m³ / h was subjected to recovery. The mesh of the strainer was 400 μm, and Purrier GS (hydrophilized PVDF, pore size 0.02 μm, external pressure type) made by Kuraray was used as the MF membrane. As the RO membrane, KROA-2032-SN (polyamide ultra low pressure RO membrane) manufactured by Kurita Water Industries Ltd. was used. Backflushing frequency of the MF apparatus was 30 minutes, and sodium hypochlorite was added at 100 mg / L during backwashing. The backwash water of the MF unit was returned to the cooling tower. By returning backwash water of the MF unit, the water recovery rate reached 100%. The amount of backwash water per one backwashing step was 1 m³.

[0057]

The pH of the blow water was 8.5 - 8.7, but sulfuric acid was added before the RO membrane apparatus so that the pH was 5.5. As the amount of water in the RO membrane unit, decreases with time elapsed, the RO membrane unit was washed with a sodium hydroxide solution adjusted to pH 11 every three months. The washing waste was returned to the cooling tower. The amount of water of the cleaning liquid was 4 m³. The water recovery rate of the RO membrane device was at 70 to 75%. Due to the recovery of the backwash water and the wash drainage, the washing treatment did not affect the water recovery rate, and the total water recovery rate remained at 70 to 75%.

[0058]

Turbidity in the backwashing drainage was removed with the side filter, and the turbidity was stable at 5 to 7 degrees. The sodium hypochlorite added during the backwashing was consumed in the cooling tower, and the chlorine concentration was maintained at 0.1 to 0.2 mg / L. Concentration of combined chlorine changed at 0.8 ~ 1.0 mg / L.

[0059]

[Comparative Example 1]

The same treatment as in Example 1 was carried out except that the backwashing waste water of the MF apparatus and the washing drainage of the RO membrane apparatus were discharged outside the system and not returned to the cooling tower. The water recovery rate of the MF membrane was 90%, and the water recovery rate of the RO membrane device was 68 to 73%. Therefore, the total water recovery rate remained at 61 to 65%.

[0060]

Reduction treatment and pH neutralization treatment were required to discharge the backwash wastewater and the washing effluent outside the system.

[0061]

[Example 2]

The same treatment as in Example 1 was carried out in the cooling tower system similar to Example 1 except that the side filter 14 was not installed in the cooling tower system. As a result, the amount of turbidity in the system gradually increased, and it became 50 degrees or more in 10 days, so the treatment was stopped.

[0062]

[Example 3]

The same treatment as in Example 1 was carried out except that the amount of water held in the cooling tower was 100 m^3 . There was no effect of returning the backwash water of the MF apparatus. However, when washing drainage from the RO membrane device was returned, the pH fluctuated and the CaCO_3 scale precipitated in the system, so the return was stopped.

[0063]

[Discussion]

As described above, according to the circulating cooling water treatment method and apparatus of the present invention, by returning the backwashing drainage and the washing drainage during the recovery process to the cooling tower, the water recovery rate can be increased. This eliminates the need for wastewater treatment. The

present invention is economically superior, and enables stable treatment at a high recovery rate.

[0064]

Although the present invention has been described in detail using specific embodiments, it will be apparent to those skilled in the art that various modifications are possible without departing from the spirit and scope of the present invention.

This application is based on Japanese Patent Application No. 2015-072960 filed on March 31, 2015, the entirety of which is incorporated by reference.

[Explanation of sign]

[0065]

- 1 Cooling tower
- 4 Heat exchanger
- 14 Side filter
- 25 Water treatment apparatus
- 30 Filter
- 33 Pretreatment membrane device
- 38 RO membrane device

Claims

1. A water treatment method comprising:
 - supplying blowing water of a cooling tower to a membrane separation apparatus,
 - supplying membrane permeated water from the membrane separation apparatus to the cooling tower, and supplying a part or the whole of water discharged from the membrane separation apparatus to the cooling tower,
 - wherein the membrane separation apparatus includes a pretreatment membrane device and a reverse osmosis membrane device, and the pretreatment membrane device has at least a microfiltration membrane or an ultrafiltration membrane,
 - wherein the water discharged from the membrane separation apparatus is at least one of backwash waste water from the pretreatment membrane device, circulating water, concentrated water, and chemical washing waste water from the pretreatment membrane device,
 - wherein the circulating water is discharged water discharged when a injection step or a circulation step for filling a housing with water, is performed at the beginning of operation of the pretreatment membrane device or during an air removal step after the backwashing, and
 - wherein the water discharged from the membrane separation apparatus is directly supplied into the cooling tower from the membrane separation apparatus.

2. The water treatment method according to claim 1, wherein the cooling tower includes a filtration device for circulating and filtering at least a part of cooling water.

3. The water treatment method according to claim 1, wherein a water supply pipe for feeding water from the cooling tower to a filtering device for circulating and filtering at least a part of the cooling water is connected to the cooling tower; and

wherein the water discharged from the membrane separation apparatus is supplied to the vicinity of the water supply pipe-connecting portion in the cooling tower.

4. A water treatment apparatus comprising:

a membrane separation apparatus,

means for supplying blowing water of a cooling tower to the membrane separation apparatus,

means for supplying membrane permeated water from the membrane separation apparatus to the cooling tower, and

means for supplying a part or the whole of water discharged from the membrane separation apparatus to the cooling tower,

wherein the membrane separation apparatus includes a pretreatment membrane device and a reverse osmosis membrane device, and the pretreatment membrane device has at least a microfiltration membrane or an ultrafiltration membrane,

wherein the water discharged from the membrane separation apparatus is at least one of backwash waste water from the

pretreatment membrane device, circulating water, concentrated water, and chemical washing waste water from the pretreatment membrane device,

wherein the circulating water is discharged water discharged when a injection step or a circulation step for filling a housing with water, is performed at the beginning of operation of the pretreatment membrane device or during an air removal step after the backwashing, and

wherein the water discharged from the membrane separation apparatus is directly supplied into the cooling tower from the membrane separation apparatus.

5. The water treatment apparatus according to claim 4, wherein the cooling tower includes a filtration device for circulating and filtering at least a part of cooling water.

6. The cooling tower according to claim 4, wherein a water supply pipe is connected to the cooling tower, the supply pipe being for feeding water from the cooling tower to a filtration device for circulating and filtering at least a part of the cooling water; and wherein the water discharged from the membrane separation apparatus is supplied to the vicinity of the water supply pipe-connection portion in the cooling tower.