DESCRIPTION

TITLE OF INVENTION: METHOD FOR REMOVING ORGANIC DISSOLVED SUBSTANCE IN WATER/VAPOR CYCLE

Technical Field

[0001] The present invention relates to a method for removing an organic dissolved substance in a water/vapor cycle.

Related Art

[0002] In recent years, attention to the quality of vapor used in factories has been increasing. In particular, in the beverage and food industries, it is necessary to reduce the effects of chemical substances on the human body, and in semiconductor factories, it is necessary to reduce impurities in humidification vapor.

[0003] From the perspective of carbon neutrality, the need for efficient heat exchange is also high, and in recent years, organic agents (dropwise condensation promoters) that achieve dropwise condensation have been utilized. For example, for the purpose of improving the heating efficiency of vapor-type heat exchangers, chemical agents such as polyamines may be added to boiler feedwater or vapor (Patent Document 1).

[0004] Some of these chemical agents are contained in recovered drain water, and together with makeup water, circulate within the system again as boiler feedwater.

[0005] In thermal power plants, two types of condensate treatment systems have conventionally been used: a single system using only a condensate demineralizer, and a combined system using a condensate pre-filtration device and a condensate demineralizer. According to this desalination system, corrosion products and ions that are generated from the structural materials of the plant and present in trace amounts in the condensate are removed, and seawater components are removed in the event of leakage of seawater or fresh water used as cooling water for the condenser.

Prior Art Documents

Patent Documents

[0006] Patent Document 1: Japanese Patent Application Laid-Open Publication No. 2019-56524.

SUMMARY OF INVENTION

Technical Problem

[0007] In the case of directly supplying a portion of the vapor generated from the boiler to vapor-use locations other than heat exchangers, it is necessary to sufficiently remove the organic agents contained in this vapor.

[0008] The present invention has an object of providing a method for removing an organic dissolved substance in a water/vapor cycle, which is capable of simultaneously achieving both improvement in efficiency of a heat exchanger by addition of a dropwise condensation promoter and the like, and removal of organic dissolved substances in a water/vapor cycle system excluding the target heat exchanger.

[0009] The gist of the present invention is as follows.

[0010] [1] A method for removing an organic dissolved substance in a water/vapor cycle in which an organic chemical is added upstream of a heat exchanger, the method for removing an organic dissolved substance in a water/vapor cycle including: passing at least a portion of drain water of the heat exchanger through a filtration device to remove the organic dissolved substance, in which a plurality of apparatuses each including at least one of an ion exchange device, an activated carbon filtration device, an RO membrane device, and an NF membrane device are arranged in parallel as the filtration device, and

drain water is passed through a portion of the apparatuses, and upon determining that a filtration performance of the portion of the apparatuses has decreased based on a chemical addition amount or a water quality measured value from a sensor, water flow-through is switched to another of the apparatuses.

[0011] [2] In the method for removing an organic dissolved substance in a water/vapor cycle according to [1], the sensor is any one or more of an electrical conductivity meter, a pH meter, a chemical concentration meter, and a crystal oscillator.

[0012] [3] In the method for removing an organic dissolved substance in a water/vapor cycle according to [1], the filtration device is switched based on either a threshold value or a trend of the sensor.

[0013] [4] In the method for removing an organic dissolved substance in a water/vapor cycle according to [1], a filter medium in the filtration device has a history of use in separate equipment, and a cartridge filled with a filter medium or the filter medium alone is replaceable.

[0014] [5] In the method for removing an organic dissolved substance in a water/vapor cycle according to [1], a switching operation signal of the apparatuses is transmitted externally to prompt an operation manager to replace the filtration device.

[0015] [6] In the method for removing an organic dissolved substance in a water/vapor cycle according to [1], the filtration device is installed downstream of a heat exchanger to which a chemical is added immediately before the heat exchanger.

[0016] [7] A method for removing an organic dissolved substance in a water/vapor cycle in which an organic chemical is added upstream of a heat exchanger, the method for removing an organic dissolved substance in a water/vapor cycle including passing at least a portion of drain water of the heat exchanger through an electrodeionization device to remove the organic dissolved substance.

[0017] [8] In the method for removing an organic dissolved substance in a water/vapor cycle according to any one of [1] to [7], the organic chemical is a dropwise condensation promoter.

Effects of Invention

[0018] According to the method for removing an organic dissolved substance in a water/vapor cycle of the present invention, it is possible to simultaneously achieve both improvement in efficiency of the heat exchanger by addition of a dropwise condensation promoter and the like,

and removal of the organic dissolved substance in the water/vapor cycle system excluding the target heat exchanger for dropwise condensation.

[0019] Further, in one aspect of the present invention, by using a disposable basis rather than resin regeneration and the like, a regeneration device is also unnecessary, so the device size is small, and the hurdle for facility introduction may be remarkably reduced.

[0020] In one aspect of the present invention, by filtering the organic chemical intentionally added immediately before a specific heat exchanger at the drain at the outlet, the organic chemical is prevented from diffusing throughout the entire water/vapor cycle system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

[FIG. 1] is a flow diagram illustrating a method for removing an organic dissolved substance in a water/vapor cycle according to an embodiment.

[FIG. 2] is a flow diagram illustrating a method for removing an organic dissolved substance in a water/vapor cycle according to an embodiment.

[FIG. 3] is a flow diagram illustrating a method for removing an organic dissolved substance in a water/vapor cycle according to an embodiment.

[FIG. 4] is a flow diagram illustrating a method for removing an organic dissolved substance in a water/vapor cycle according to an embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0022] An example of the method for removing an organic dissolved substance in a water/vapor cycle of the present invention is shown in FIG. 1 to FIG. 4.

[0023] In FIG. 1 to FIG. 3, vapor generated in the boiler 1 is sent through piping 2 to the heat exchanger 3. The vapor is cooled and condensed in the heat exchanger 3 to become drain water. This drain water flows from piping 4 through a three-way valve 5 into piping 6 or 7, and flows

into filtration device (dropwise condensation promoter removal device in this embodiment) A or B, where dropwise condensation promoter removal treatment is performed. The treated water that has undergone the dropwise condensation promoter removal treatment is returned to the boiler 1 from piping 8 or 9 through piping 10. Along the way, makeup water is supplied from makeup water piping 11.

[0024] In the piping 2, a dropwise condensation promoter is added as an organic dissolved substance by a dropwise condensation promoter addition device 20. The dropwise condensation promoter addition device 20 includes a chemical tank for storing a chemical solution, a chemical injection pump, a chemical addition line, and the like.

[0025] The three-way valve 5 is controlled by a controller 21 as follows.

[0026] In FIG. 1, the dropwise condensation promoter addition device 20 is provided with a mechanism for detecting the amount of chemical addition.

[0027] At the start of operation, the three-way valve 5 first connects piping 4 and 6 so that water flows through the filtration device A. In response to the cumulative amount of chemical addition approaching the preset upper limit of the chemical adsorption capacity of the filtration device A, the three-way valve 5 is switched to allow water to flow through the filtration device B. While water is flowing through the filtration device B, the filter medium of the filtration device A is replaced. The water flow switching from the filtration device B to the filtration device A is performed in the same manner.

[0028] The amount of chemical addition may be calculated from the decrease in the chemical solution in the chemical tank, or may be calculated from the detected value of a flow meter provided in the chemical addition line or the operating time of the chemical injection pump.

[0029] Another aspect of the present invention is shown in FIG. 2. In FIG. 2, a water quality sensor 22 for detecting water quality such as the dropwise condensation promoter concentration is provided in piping 10.

[0030] The water quality sensor 22 continuously monitors water quality, and in the case where the sensor value corresponding to the organic chemical concentration exceeds the threshold value, or in the case where the sensor value exhibits a predetermined trend variation (variation in time-series data), the three-way valve 5 is switched to switch the filtration device through which water flows. As the water quality sensor 22, one or two or more of an electrical conductivity meter, a pH meter, a crystal oscillator, and the like, in addition to a chemical concentration meter, may be used.

[0031] Yet another aspect of the present invention is shown in FIG. 3. In FIG. 3, a concentration sensor 24 for detecting the concentration of the added chemical is provided in piping 4, and a flow meter 25 for detecting the drain flow rate is provided in piping 10. It is noted that the flow meter 25 may be provided in piping 4.

[0032] The detected values of the concentration sensor 24 and the drain flow meter 25 are input to the controller 21, and the three-way valve 5 is switched in response to the load (the cumulative value over time of the product of concentration and flow rate) approaching the upper limit of the filtration device. It is noted that instead of the drain flow meter 25, a vapor flow meter installed upstream of the heat exchanger may be used to determine the drain flow rate passing through the filtration device A or B.

[0033] FIG. 4 shows yet another aspect of the present invention. In FIG. 4, drain from the heat exchanger 3 is sent via piping 4 to the electrodeionization device 30, and the deionized treated water is sent via piping 10 to the boiler 1. The other configurations are the same as those in FIG. 1.

[0034] In FIG. 1 to FIG. 4, vapor generated in the boiler is supplied only to the heat exchanger 3 to which a single organic chemical is added, but the present invention is not limited thereto.

[0035] Further, in FIG. 1 to FIG. 4, the entire amount of drain that has passed through the target heat exchanger is passed through the filtration device (referred to as the dropwise condensation promoter removal device in the figures) or the electrodeionization device, but a portion thereof

may also be passed through, or the drain may be passed through together with vapor and drain from other systems. In the case where the filtration device or the electrodeionization device is unable to process high-temperature drain (for example, at 60°C or higher), the water temperature may be lowered by combining the drain with low-temperature water from other systems or the like before passing the water through.

[0036] In FIG. 1 to FIG. 3, the filtration equipment is installed with two systems in parallel, but three or more systems may be installed in parallel and switched as needed.

[0037] It is noted that the removal level of organic dissolved substances may be complete removal or reduction, and the removal level may be determined according to, for example, the required concentration.

[0038] Examples of the filtration device (dropwise condensation promoter removal device) used in FIG. 1 to FIG. 3 include an ion exchange resin tower, an activated carbon tower, an RO membrane device, and an NF membrane device.

[0039] From an economic standpoint, it is desirable to select an anion exchange resin, a cation exchange resin, or a mixed-bed resin as the ion exchange resin, according to the type of organic agent to be added.

[0040] For example, in the case where the chemical to be added is a polyamine (specifically, OLDA (N-oleyl-1,3-propanediamine)), it is preferable to use a cation exchange resin, and in the case of sarcosinates, it is preferable to use an anion exchange resin.

[0041] In addition, it is desirable that the ion exchange resin be one that is resistant to deterioration even in high-temperature drain water.

[0042] More preferably, from the standpoint of preventing elution of impurities, it is desirable that the filtration device be an ion exchange resin tower using a high-specification ion exchange resin that has been used in facilities with a high level of pure water quality, or an RO membrane device.

[0043] In the present invention, a heat exchanger for a drain cooling portion for cooling drain water may be installed upstream of the filtration device. By doing so, the container (vessel) of the filtration device housing the filter medium used in a disposable manner may be made of a non-metallic material, thereby improving operability and economic efficiency.

[0044] It is noted that in the case of using an RO membrane device or an NF membrane device as the filtration device, this applies to the embodiments of FIG. 1 and FIG. 2.

Examples

[0045] [Example 1]

<Experimental Conditions>

In a water/vapor cycle having the configuration of FIG. 1, operation was carried out at a vapor generation rate of 10 t/hr during steady-state operation of the boiler and at a working pressure of 0.78 MPa. Regarding the vapor usage, the amount used in the direct vapor injection facility was 1 t/hr, and the remaining 9 t/hr was used in heat exchangers for heating. Further, the configuration was such that vapor was diverted from piping 2 to supply a portion of the vapor to the direct vapor injection facility.

[0046] The drain water from the heat exchanger was filtered by the filtration device A or B, after which makeup water was supplied, and the water was used again as boiler feedwater. Ion exchange towers were installed as the filtration devices A and B. First, water was passed through the removal device A.

[0047] As a dropwise condensation promoter, a chemical agent containing N-oleyl-1,3-propanediamine as the main component was added at 20 ppm relative to the vapor amount.

[0048] Further, a liquid level gauge was provided in the chemical tank of the dropwise condensation promoter addition device 20, and a mechanism was provided to calculate the chemical injection amount from the tank based on the detected value of the liquid level gauge and transmit an output signal externally.

[0049] The threshold value at which the ion exchange resin reaches breakthrough was set to 80% of the value calculated from the theoretical value, and the system was configured to transmit a three-way valve switching signal in response to this threshold value being exceeded.

[0050] The filtration devices A and B were filled with high-grade ion exchange resin that had been reused from another plant where it had been used for ultrapure water production.

[0051] <Results and Discussion>

By continuously adding the chemical agent at 20 ppm relative to the vapor amount, the expected improvement in heat transfer efficiency was obtained in heat exchanger 3. Further, drain water was collected from piping 10 and analyzed, and the concentration of organic substances derived from the chemical was zero, with no detection whatsoever. Furthermore, even upon analyzing the vapor from the direct vapor injection facility, the organic substance concentration was likewise zero.

[0052] Two months after water was started flowing through the filtration device A, based on the cumulative usage amount of the chemical, the three-way valve 5 was switched, and simultaneously with the water switched to flow through the filtration device B, an instruction signal was sent externally to instruct the replacement of the resin in the filtration device A.

[0053] [Comparative Example 1]

<Experimental Conditions>

In FIG. 1, the three-way valve 5, the piping 6, 7, 8, and 9, and the filtration devices A and B were omitted, and the piping 4 and 10 were directly connected. Other than this, the test was conducted under exactly the same conditions as in Example 1.

[0054] <Results and Discussion>

The chemical component concentration detected in the direct vapor injection facility was 0.14 mg/L, which failed to satisfy the vapor quality standard requiring no TOC components in the vapor. The chemical component analysis was performed by condensing the vapor using a temporary heat exchanger (not shown) for cooling the vapor, and then measuring the condensate.

[0055] From the above, it was confirmed that by filtering and removing the organic chemical added upstream of heat exchanger 3 from the drain, the organic chemical may be prevented from diffusing throughout the entire water/vapor cycle system.

[0056] The present invention has been described in detail using specific aspects; however, it is apparent to those skilled in the art that various modifications are possible within the scope in which the effects of the invention are achieved.

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This application is based on Japanese Patent Application No. 2024-066945 filed on April 17, 2024, the entirety of which is incorporated by reference.

Reference Signs List

[0058]

1 Boiler

3 Heat exchanger

5 Three-way valve

20 Dropwise condensation promoter addition device

21 Controller

30 Electrodeionization device

CLAIMS

[Claim 1]

A method for removing an organic dissolved substance in a water/vapor cycle in which an organic chemical is added upstream of a heat exchanger, the method for removing an organic dissolved substance in a water/vapor cycle comprising: passing at least a portion of drain water of the heat exchanger through a filtration device to remove the organic dissolved substance,

wherein a plurality of apparatuses each comprising at least one of an ion exchange device, an activated carbon filtration device, an RO membrane device, and an NF membrane device are arranged in parallel as the filtration device, and

drain water is passed through a portion of the apparatuses, and upon determining that a filtration performance of the portion of the apparatuses has decreased based on a chemical addition amount or a water quality measured value from a sensor, water flow-through is switched to another of the apparatuses.

[Claim 2]

The method for removing an organic dissolved substance in a water/vapor cycle according to claim 1, wherein the sensor is any one or more of an electrical conductivity meter, a pH meter, a chemical concentration meter, and a crystal oscillator.

[Claim 3]

The method for removing an organic dissolved substance in a water/vapor cycle according to claim 1, wherein the filtration device is switched based on either a threshold value or a trend of the sensor.

[Claim 4]

The method for removing an organic dissolved substance in a water/vapor cycle according to claim 1, wherein a filter medium in the filtration device has a history of use in separate equipment, and a cartridge filled with a filter medium or the filter medium alone is replaceable.

[Claim 5]

The method for removing an organic dissolved substance in a water/vapor cycle according to claim 1, wherein a switching operation signal of the apparatuses is transmitted externally to prompt an operation manager to replace the filtration device.

[Claim 6]

The method for removing an organic dissolved substance in a water/vapor cycle according to claim 1, wherein the filtration device is installed downstream of a heat exchanger to which a chemical is added immediately before the heat exchanger.

[Claim 7]

A method for removing an organic dissolved substance in a water/vapor cycle in which an organic chemical is added upstream of a heat exchanger, the method for removing an organic dissolved substance in a water/vapor cycle comprising passing at least a portion of drain water of the heat exchanger through an electrodeionization device to remove the organic dissolved substance.

[Claim 8]

The method for removing an organic dissolved substance in a water/vapor cycle according to any one of claims 1 to 7, wherein the organic chemical is a dropwise condensation promoter.