

Description

DESCALING APPARATUS AND DESCALING SYSTEM USING SAME

[Field of invention]

[0001] The invention relates to a descaling apparatus and a descaling system using the same.

[Background of invention]

[0002] In buildings where refrigeration and freezing equipment, etc. with significant electricity consumption is used, a cooling system using a cooling tower is used to cool the refrigeration and freezing equipment, etc. Such a cooling system can cool the inside of the building and objects to be cooled in the building, etc., for example, by installing a cooling tower on the roof, etc. of the building, supplying a refrigerant such as water via pipes installed throughout the building, and absorbing heat with the refrigerant.

[0003] Increasing the energy efficiency of this cooling system requires an efficient exchange of the cold of the refrigerant with the material to be cooled. However, when using water as a refrigerant, it is known that calcium and magnesium contained in the water aggregate due to electrical attraction to form scale, which is deposited on the cooling tower or inside the pipes, thereby inhibiting heat exchange.

[0004] For example, Patent document 1 below discloses a technology that aims to supply a decaying wave signal by providing an electrostatic rectifier in the pipes, thereby increasing the cooling efficiency as well as descaling the pipes.

[Prior art document]

[Patent document]

[0005]

[Patent document 1] Japanese Patent No. 6906213.

[Summary of invention]

[Problems to be solved by invention]

[0006] However, the technology described in Patent document 1 above requires the provision of an electrostatic rectifier in the path of the cooling system itself, which poses the problem that the cooling system needs to be stopped once to upgrade the entire cooling system.

[0007] The technology described in Patent document 1 above still leaves room for improvement in terms of descaling efficiency.

[0008] In view of the above-mentioned problems, the purpose of the present invention is to provide a descaling apparatus and a descaling system using the same that can achieve high descaling efficiency without the need for major upgrading of the system.

[Means to solve problems]

[0009] A descaling apparatus according to an aspect of the present invention to solve the above problem is a descaling apparatus comprising: a circulation pipeline that transports cooling water contained in a cooling tower and returns cooling water to the cooling tower; and a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

[0010] Although not limited in this aspect, the water quality activator preferably comprises a charge vessel that is charged with a water quality activating agent inside; an introduction pipe for introducing cooling water into the charge vessel; and a discharge pipe connected to the charge vessel for discharging cooling water.

[0011] Although not limited in this aspect, the electrostatic rectifier preferably comprises a signal generation circuit for generating a decaying wave signal; and an electrical wiring for applying the decaying wave signal generated by the signal generation circuit to cooling water.

[0012] Although not limited in this aspect, the decaying wave signal is preferably a pulsed decaying wave signal repeating at a frequency of 20 kHz or higher and 60 kHz or lower.

[0013] A descaling system according to another aspect of the present invention is a descaling system comprising: a cooling tower containing cooling water; a facility pipeline connected to the cooling tower and passing through a facility; and a descaling apparatus provided in the cooling tower, wherein the descaling apparatus comprising: a circulation pipeline that transports cooling water contained in the cooling tower and returns cooling water to the cooling tower; and a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

[0014] Although not limited in this aspect, the water quality activator preferably comprises a charge vessel that is charged with a water quality activating agent inside; an introduction pipe for introducing cooling water into the charge vessel; and a discharge pipe connected to the charge vessel for discharging cooling water.

[0015] In this aspect, the water quality activating agent preferably comprises a resin strip and fine-grained ceramic particles kneaded into the resin strip.

[0016] In this aspect, the water quality activating agent is preferably grained ceramic particles prepared by graining and sintering at least one of montmorillonite and stromatolite.

[0017] Although not limited in this aspect, the electrostatic rectifier preferably comprises a signal generation circuit for generating a decaying wave signal; and an electrical wiring for applying the decaying wave signal generated by the signal generation circuit to cooling water.

[0018] Although not limited in this aspect, the decaying wave signal is preferably a pulsed decaying wave signal repeating at a frequency of 20 kHz or higher and 60 kHz or lower.

[0019] A descaling apparatus according to another aspect of the present invention is a descaling apparatus comprising: a circulation pipeline; and a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

[0020] A descaling system according to another aspect of the present invention is a descaling

system comprising: a facility pipeline passing through a facility; and a descaling apparatus provided in the facility pipeline, wherein the descaling apparatus comprising: a circulation pipeline that transports water and returns the water to the facility pipeline; and a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

[Effects of invention]

[0021] The invention described above provides a descaling apparatus and a descaling system using the same that can achieve high descaling efficiency without the need for major upgrading of the system.

[Brief description of drawings]

[0022]

FIG. 1 is a functional block diagram of a descaling system in an embodiment.

FIG. 2 is a conceptual illustration of charged water molecules.

FIG. 3 is a schematic diagram illustrating an example of a water quality activating agent of the embodiment.

FIG. 4 is a schematic diagram illustrating another example of the water quality activating agent of the embodiment.

FIG. 5 is a schematic diagram illustrating a cross-section of a water quality activator of the embodiment.

FIG. 6 is a schematic diagram illustrating an electrostatic rectifier of the embodiment.

FIG. 7 is an example of a waveform of a pulsed decaying wave signal generated by the electrostatic rectifier of the embodiment.

FIG. 8 is a diagram illustrating a functional block of a signal generation circuit of the electrostatic rectifier of the embodiment.

FIG. 9 is a diagram illustrating an equivalent circuit of the signal generation circuit of the electrostatic rectifier of the embodiment.

[Description of embodiments]

[0023] The following is a detailed description of the embodiment of the present invention with reference to the drawings. Note, however, that the present invention can be implemented in many different embodiments and is not limited only to the specific forms described in the embodiment and examples shown below.

[0024] FIG. 1 is a diagram illustrating a cooling system S of the embodiment (hereafter referred to as "the system"). As illustrated in the figure, the system S is a system comprising a cooling tower CT containing cooling water, a facility pipeline P connected to the cooling tower CT and passing through a facility, and a descaling apparatus 1 provided in the cooling tower CT, wherein the descaling apparatus 1 comprising: a circulation pipeline 2 that transports cooling water contained in the cooling tower CT and returns cooling water to the cooling tower CT; and a pump 3, a water quality activator

4 and an electrostatic rectifier 5 provided in a path of the circulation pipeline.

[0025] The cooling tower CT in the system S is used to cool the cooling water used in the system S. The cooling water is in contact with the outside atmosphere (air) to transfer heat from the outside atmosphere and evaporate a part of the cooling water, thereby cooling the outside atmosphere and the rest of the cooling water. The specific configuration is not limited, but the cooling tower CT preferably comprises, at least, a heat exchanger for evaporating the cooling water and exchanging heat, a lower water tank for collecting the cooling water that has not evaporated, a fan for ventilation and a casing for housing the heat exchanger, a cooling pan and the fan. Note that the lower part of the casing may have the function of serving as a lower water tank.

[0026] Then, the cooling water cooled as described above circulates around the facility via the facility pipeline P, which is installed throughout the facility and connected to the cooling tower CT, or more specifically, the lower water tank of the cooling tower CT, and exchanges heat with the equipment and devices to be cooled (hereafter also referred to as "equipment, etc. to be cooled") to cool the equipment, etc. to be cooled. Note that the facility pipeline P is preferably made of a material with high thermal conductivity from the viewpoint of facilitating heat exchange when exchanging heat and is preferably, for example, made of a metal. The facility pipeline P is configured so that water circulates around the facility and then returns again to the cooling tower CT.

[0027] As is clear from the above description, "cooling water" here refers to water used to cool the equipment, etc. to be cooled in the facility, which is sent into the facility with the facility pipeline P and used as a medium for heat exchange with each of the equipment, etc. to be cooled. The cooling water system is connected in many cases to an external water supply source, such as a water service pipeline, via a valve V that can be opened and closed, so that cooling water can be supplied as necessary when the water decreases due to evaporation or when the water decreases after being discharged out of the system due to the concentration of dissolved substances in the cooling water exceeding a specific level. As is also clear from this description, the cooling water contains dissolved substances such as magnesium and calcium ions that are unavoidable, which precipitate due to various causes such as evaporation of the cooling water, precipitate inside the pipes, etc., and is deposited on the inner walls of the pipes to form scale. This scale generally has low thermal conductivity, significantly decreasing the cooling efficiency due to its interposition between the cooling water and the equipment, etc. to be cooled that is being cooled.

[0028] In the system S, as described above, the descaling apparatus 1 is therefore provided, which enables descaling as well as scale precipitation to be reduced, thereby maintaining the cooling efficiency of the cooling system as a whole at a high level. As is clear from the description above, the descaling apparatus 1 of the system S is provided in the cooling tower CT and is capable of suctioning the cooling water temporarily held in the cooling tower CT, more specifically, the cooling water contained in the lower water tank of the cooling tower CT, descaling the cooling water system while

preventing scale precipitation, and returning the cooling water again to the cooling tower CT.

[0029] The descaling apparatus 1 of the system S has the circulation pipeline 2, as described above. The circulation pipeline 2 forms a so-called independent circulation path, where one opening (suction port) is immersed in the cooling water contained in the cooling tower CT to transport the cooling water while returning the cooling water to the cooling tower CT through the other opening (outlet port) after letting the cooling water pass through the pump 3, the water quality activator 4 and the electrostatic rectifier 5.

[0030] The material for the circulation pipeline 2 in the descaling apparatus 1 is not limited as long as it has the above functions and can be, for example, a metal or a resin, and although the material is not particularly limited, at least the portion where a signal is applied by the electrostatic rectifier 5 is preferably made of a conductive material, such as a metal.

[0031] The descaling apparatus 1 of the system S has the pump 3 in the path (in the middle) of the circulation pipeline 2, as described above. The positioning of the pump 3 is not limited as long as it is in the path of the circulation pipeline 2. It can be provided in any part of the circulation pipeline 2, and the location is not limited, whether immediately after the water quality activator 4 or immediately after the electrostatic rectifier 5. Note that the type of the pump 3 in the system S is not limited as long as it has the above functions and can be a positive displacement pump or a non-positive displacement pump. Examples of positive displacement pumps include reciprocating vibration pumps such as piston pumps, plunger pumps and diaphragm pumps, and rotary pumps such as gear pumps and screw pumps, while examples of non-positive displacement pumps include centrifugal pumps such as volute pumps and turbine pumps, propeller pumps such as axial flow pumps and mixed-flow pumps, and viscous pumps such as cascade pumps.

[0032] The descaling apparatus 1 of the system S has the water quality activator 4, as described above. The water quality activator 4 is a device that brings the cooling water into contact with a water quality activating agent 41 inside, thereby, in combination with the electrostatic rectifier 5, synergizing the effects of descaling to make descaling effective.

[0033] In the descaling apparatus 1, the "water quality activating agent" refers to an agent that imparts water activation to the cooling water, and although not limited, examples include ceramics. Ceramic surfaces are negatively charged due to charge bias or dissociation of the ceramics themselves when pieces of ceramic contact each other. When in contact with the cooling water, they relax the δ^+ hydrogen atoms of the cooling water to form small clusters of water molecules, which then interact with scale to weaken the bonds in scale and make the crystallinity of scale amorphous, making scale easier to be removed from and harder to be deposited on pipes, etc. FIG. 2 is a conceptual illustration of clusters formed by water molecules in the cooling water.

[0034] When ceramics are used as the water quality activating agent 41 in the descaling apparatus 1, although not limited as long as they have the above functions, ceramic materials are preferably made

by sintering clay minerals such as montmorillonite and stromatolite.

[0035] Although the shape of ceramics for the water quality activator 4 of the descaling apparatus 1 is not limited as long as it has the above functions and may be granular as they are (for example, spherical grains with an average grain diameter of 5 mm or larger and 30 mm or smaller), to enhance their effect, they may be fine-grained with an average grain diameter of 100 μm or smaller, more preferably about 10 μm and may be stably supported by a binder such as a resin. In this way, the contact area between the ceramics and the cooling water can increase, while they can effectively be prevented from leaking out. Note that, in this case, the weight ratio of ceramics to the whole water quality activating agent, including resins, is preferably 70 and more and 99 or less to 100.

[0036] FIG. 3 is a conceptual illustration of the water quality activating agent 41 in the water quality activator 4 in the case described above. More specifically, the water quality activating agent in the water quality activator 4 preferably comprises a resin strip and fine-grained ceramic particles kneaded into the resin strip, more preferably with this resin strip curled up in contact with each other at the edges, etc. In this way, the contact area between the ceramics and the cooling water can be stably secured, the total volume of the water quality activating agent can be prevented from increasing, and it can be easily contained in the charge vessel 42 of the water quality activator 4. In particular, the form of the resin strips curled up in this way has the advantage that, even when the vessel is filled with them, sufficient water flow can be ensured through gaps between them.

[0037] Another conceptual illustration of a different type of water quality activating agent 41 in the descaling apparatus 1 is shown in FIG. 4. Figure (a) shows the external appearance and (b) its cross-section. The different type of water quality activating agent shown in this figure has a base body 411, a glaze layer 412 covering the base body 411 and fine-grained ceramic particles 413 dispersed in the glaze layer 412. In this way, fine-grained ceramic particles can be securely supported, and their effects can be demonstrated by supporting the fine-grained ceramic particles in the glaze layer.

[0038] In this water quality activating agent, the "base body" refers to the foundation for supporting the above-mentioned glaze layer 412, which, although not limited in this respect, is preferably a piece of earth (including clay) kneaded and sintered. The shape of the base body 411 is not limited but preferably spherical. By making it spherical, the contact area between the base bodies or between the base bodies and the charge vessel 42 for the water quality activating agent can be minimized to allow the gaps between them to prevent the water flow from being obstructed. Note that when the base body is spherical, it does not have to be a perfect sphere, and it is acceptable to have some unevenness or distortion. The size of this sphere varies greatly depending on the size of the charging device used, but its diameter is preferably 5 mm or larger and 5 cm or smaller, and more preferably 3 cm or smaller.

[0039] The "glaze layer" refers to the layer of glaze formed by sintering after applying glaze to the surface of the base body prior to sintering when sintering the above-mentioned base body. As

described above, the glaze layer contains fine-grained ceramic particles, which ensures that they are securely supported in the glaze layer by sintering. Any known glaze can be employed as a glaze and is not limited to any particular one. The same applies to fine-grained ceramic particles as in the case of the above-mentioned resin strips.

[0040] Although not limited in the system S, the water quality activator 4 preferably comprises the charge vessel 42 that is charged with the water quality activating agent 41 inside, an introduction pipe 43 for introducing the cooling water into the charge vessel 42 and a discharge pipe 44 connected to the charge vessel 42 for discharging the cooling water. FIG. 5 is a schematic diagram illustrating a cross-section of the water quality activator 4 of the descaling apparatus 1.

[0041] In the water quality activator 4, the charge vessel 42 is, as described above, for being filled with the water quality activating agent 41 and for bringing the water quality activating agent 41 into contact with the cooling water. The charge vessel 42 is preferably a cylindrical member, and in the example shown in this figure, it is preferably a pair of a bottomed cylindrical member and a lid member that closes its open end. The material for the charge vessel 42 is not limited but preferably a metal or a resin that does not easily degrade due to contact with the cooling water, and in the case of a metal, it is preferably made of stainless steel.

[0042] In the water quality activator 4, the introduction pipe 43 is connected to be located in the middle of the circulation pipeline 2 to introduce the cooling water into the charge vessel 42. The introduction pipe 43 is not particularly limited in its configuration and is preferably made of a metal or a resin that does not easily corrode by the cooling water, as in the case of the circulation pipeline 2 described above. Note that the diameter of the introduction pipe 43 is not limited but is preferably 8 mm or larger to prevent clogging due to scale. When the charge vessel 42 has a bottomed cylindrical shape as described above, an open end 431 on the side not connected to the introduction pipe 43 preferably extends close to the bottom of the cylindrical shape described above. The reason for this is that providing the open end close to the bottom ensures the most efficient pathway for bringing the cooling water into contact with the water quality activating agent 41.

[0043] In the water quality activator 4, the discharge pipe 44 is connected to the circulation pipeline 2 to return the cooling water discharged from the charge vessel 42 to the circulation pipeline 2. The diameter of the discharge pipe 44 is not limited but is preferably 8 mm or larger to prevent clogging due to scale. In the case of the example shown in the figure above, i.e., where the charge vessel 42 is a combination of a bottomed cylindrical shape and its lid, an inlet 441 is preferably provided near the lid. In this way, water can be discharged outside this water quality activator 4 after the water quality activating agent 41 has been in sufficient contact with the cooling water in the charge vessel 42.

[0044] The descaling apparatus 1 of the system S has the electrostatic rectifier 5, as described above. In the system S, the combination of the water quality activator 4 and the electrostatic rectifier

5 ensures the maximum effectiveness of descaling.

[0045] The external structure of the electrostatic rectifier 5 of the descaling apparatus 1 in the system S is shown in FIG. 6. In the system S, the electrostatic rectifier 5 can generate and supply an electrical signal whose voltage (amplitude) changes with time with respect to the cooling water, specifically a decaying wave signal, preferably a pulsed decaying wave signal. As shown in this figure, the electrostatic rectifier 5 has an electrical wiring 52 wound around the circulation pipeline 2 to apply a specific electrical signal to the cooling water.

[0046] Here, the waveform of the electrical signal applied by the electrostatic rectifier 5 to the cooling water through the circulation pipeline 2 is shown in FIG. 7.

[0047] As shown in this figure, the electrostatic rectifier 5 provides an electrical signal of decaying waves whose voltage (amplitude) changes with time. Being a decaying wave signal is important in achieving efficient heat transfer. The "decaying wave signal" refers to a signal periodically repeating with its amplitude decreasing with time, which may be a harmonic wave overlapped by a pulsed signal wave. Note that the term "pulsed" means that the signal appears at regular intervals.

[0048] The electrostatic rectifier 5 preferably supplies a pulsed decaying wave signal repeating at a frequency of 20 kHz or higher and 40 kHz or lower, more preferably at 33 kHz or lower. This frequency is a so-called pulse frequency. The pulsed decaying wave signal is supplied at intervals of 20 μ s or longer and 50 μ s or shorter, more preferably 30 μ s or shorter, in terms of repetition time. The pulsed signal in the above range can supply the medium with solvated electrons in a pulsatile manner, resulting in vibrations that are transmitted to the clusters in the cooling water to help resolve the clusters, although this effect is partly speculative. By making it a decaying wave, this effect becomes more significant. Note that "solvated electrons" refers to electrons used to make a medium neutral.

[0049] In the electrostatic rectifier 5, when the signal is a decaying wave, the frequency of the signal within a single decaying wave signal is preferably 2 MHz or higher and 10 MHz or lower, more preferably 5 MHz or lower. This frequency refers to the period within a single decaying wave signal, and its time interval is 0.1 μ s or longer and 0.5 μ s or shorter, preferably 0.2 μ s or shorter. Although the effect of adding waves in this range is partly speculative, as with the pulsed decaying wave signal described above, the decaying wave signal will help to effectively transmit the impact of the pulses to the cooling water.

[0050] Although not limited as long as the structure of the descaling apparatus 1 can generate a decaying wave signal, as shown in the figure above, the electrostatic rectifier 5 preferably comprises a signal generation circuit 51 for generating a decaying wave signal; and an electrical wiring 52 for applying the decaying wave signal generated by the signal generation circuit 51 to the cooling water. A functional block of this configuration is shown in FIG. 8.

[0051] Although not limited as long as the signal generation circuit 51 can generate a decaying wave signal, the electrostatic rectifier 5 preferably comprises an AD converter that converts the AC

power to DC power, a signal generator that generates a basic signal, an operational amplifier that receives these inputs, and an output end that transmits the output of the operational amplifier. Capacitors and resistors may be arranged between these elements to adjust voltage, etc., as appropriate. An equivalent circuit of the signal generation circuit 51 is shown in FIG. 9.

[0052] Although not limited as long as the decaying wave signal generated by the signal generation circuit 51 can be applied to the cooling water, the electrical wiring 52 in the electrostatic rectifier is connected to the output end transmitting the output of the operational amplifier to provide electric charge.

[0053] Here, the mechanism of descaling with the electrostatic rectifier 5 will be described. The refrigerant used in the system S is cooling water with its molecules having polarity. The charge separation in the molecules of the cooling water generates a force between these molecules to bond with each other. However, since these molecules within the population form clusters while changing the pairing partner at each time, the application of a model with a certain dynamism (decaying wave signals) enables free electrons to be injected from outside into the cooling water, can make the clusters smaller and enables efficient descaling. In particular, the system S, by combining the electrostatic rectifier 5 and the water quality activator 4, can achieve an efficiency improvement of several tens of times higher than the case with the electrostatic rectifier 5 alone or the water quality activator 4 alone. In particular, the system S enables scale to be removed from inside the circulation pipeline 2 and discharged to the cooling tower CT, even if scale has already been deposited on the inside of the circulation pipeline 2. And furthermore, the deposition of scale can be prevented.

[0054] The embodiment described above provides a descaling apparatus and a descaling system using the same that can achieve high descaling efficiency without the need for major upgrading of the system. To describe the effects more specifically, as the system comprises the water quality activator and the electrostatic rectifier, the effects of electrical signals generated by the electrostatic rectifier are more easily demonstrated when the water is activated by the water quality activator, and the effects are synergistically and dramatically improved, resulting in a dramatically higher descaling efficiency than in the case of using the water quality activator alone or the electrostatic rectifier alone. To describe this more specifically, as is clear from the experimental examples described below, scale that normally occurs as crystalline material is replaced by amorphous scale, which is finer, harder to be deposited and easier to be removed, while also becoming less likely to stick to the inside of pipes, etc. As a result, the functions of a descaling apparatus can be fully demonstrated.

[0055] In particular, the system has the advantage of being easily installed without the need for major upgrading of the system because a different circulation path passing through the cooling tower CT only needs to be provided separately from the facility pipeline P passing through the cooling tower CT and the facility. This can be a very significant advantage. It also has the advantage of enabling work to be done while keeping devices connected to the facility pipeline P in operation, even when

the system needs to be repaired or upgraded.

[0056] Note that, although the system has been described as a system using a cooling tower CT, it can fully demonstrate its effectiveness in any system that circulates water and can be applied to indoor water heating systems, etc. In summary, the system can be configured as a descaling system comprising a facility pipeline passing through a facility and a descaling apparatus provided in the facility pipeline, wherein the descaling apparatus comprising: a circulation pipeline that transports water and returns the water to the facility pipeline; and a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline. As is clear from this description, the "cooling water" used when describing the cooling tower may also be hot water and is treated simply as "water."

[Examples]

[0057] Here, a specific prototype of the system was prepared and tested to check its effectiveness. The following is a specific explanation.

[0058]

(Example 1)

First, the above descaling apparatus was installed in a building with a circulation pipeline and a cooling tower to cool the cooling apparatus, etc. (a cooling system that has already been in operation for more than a few years). Specifically, a circulation pipeline with an intake suction port and a discharging outlet port is provided in the lower water tank of the cooling tower with a pump, a water quality activator and an electrostatic rectifier arranged in series in the middle of the path. Note that the water quality activator was a water quality activator as a form of a charge vessel filled with a water quality activating agent made by mixing ceramic particles with an average particle size of about 20 μm that were produced from stromatolite with a binder resin and molding it, and the electrostatic rectifier was an electrostatic rectifier that generated electrical signals, as shown in the figure above.

[0059] Then, the effectiveness of the system was checked by driving the entire system, including the descaling apparatus described above. Specifically, in the first month after installation, 3 kg or more of scale already deposited on the pipes could be removed and collected from the lower water tank of the cooling tower. In addition, no scale precipitation was observed in the following six months of use, with no new precipitation of scale observed when checking the inside of the pipes. In particular, in this experiment, the ORP (oxidation-reduction potential) value, which is considered to be an indicator related to scale precipitation, was initially around 700 mV, but after installing the descaling apparatus, the value decreased to around 250 mV in about three hours, and the state was maintained in the same period of time even after exchanging the cooling water. The ORP value, which is considered to relate to scale deposition, has been rapidly and significantly reduced by using the descaling apparatus, suggesting that the apparatus has promoted the removal of scale and reduced the precipitation of scale. In other words, it was confirmed that the scale that had been deposited was easily removed by the

descaling apparatus, and that scale was less likely to precipitate and be deposited after its removal.

[0060]

(Example 2)

In this example, the same configuration was used, except that the binder resin in Example 1 above was replaced by spherical earthenware with an overall average grain diameter of about 1 cm, with ceramic particles with an average grain diameter of about 20 μm mixed into the glaze layer on their surfaces. Note that the spherical earthenware is shown in the figure above.

[0061] Then, the effectiveness of the system was checked by driving the entire system, including the descaling apparatus described above. Specifically, in the first month after installation, 4 kg or more of scale already deposited on the pipes could be removed and collected from the lower water tank of the cooling tower. In addition, no scale precipitation was observed in the following six months of use, with no new precipitation of scale observed when checking the inside of the pipes. In particular, in this experiment, the ORP (oxidation-reduction potential) value, which is considered to be an indicator related to scale precipitation, was initially around 700 mV, but after installing the descaling apparatus, the value decreased to around 230 mV in about three hours, and the state was maintained in the same period of time even after exchanging the cooling water. The ORP value, which is considered to relate to scale deposition, has been rapidly and significantly reduced by using the descaling apparatus, suggesting that the apparatus has promoted the removal of scale and reduced the precipitation of scale. In other words, it was confirmed that the scale that had been deposited was easily removed by the descaling apparatus, and that scale was less likely to precipitate and be deposited after its removal.

[0062]

(Comparative example 1)

A similar system to the above example was configured without a water quality activator in a different building from the above example but with a similar cooling system to conduct the same operation and the same measurements.

[0063] This apparatus showed almost no signs of removed scale in about a month after installation, with only a small amount of removal observed in half a year. Note, however, that no increase in scale was observed. The effect of preventing scale precipitation was confirmed to some extent in this result, although the descaling effect was not sufficient.

[0064]

(Comparative example 2)

A similar system to the above example was configured without an electrostatic rectifier in a different building from the above example, Comparative example 1, but with a similar cooling system to conduct the same operation and the same measurements.

[0065] This apparatus showed almost no signs of removed scale in about a month after installation, with only a small amount of removal observed even in half a year. In some locations, an increase in

scale in the pipes was observed, indicating that the descaling effect was not sufficient in this result.

[0066] The effects of the invention were confirmed by the above results.

[Industrial applicability]

[0067] The invention has industrial applicability as a descaling apparatus and a descaling system using the same.

[Reference signs list]

[0068]

S cooling system

CT cooling tower

CP cooling tower

P facility pipeline

1 descaling apparatus

2 circulation pipeline

3 pump

4 water quality activator

5 electrostatic rectifier

What is claimed is:

1. A descaling apparatus comprising:

a circulation pipeline that transports cooling water contained in a cooling tower and returns the cooling water to the cooling tower; and

a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

2. The descaling apparatus according to claim 1, wherein the water quality activator comprising:

a charge vessel that is charged with a water quality activating agent inside;

an introduction pipe for introducing the cooling water into the charge vessel; and

a discharge pipe connected to the charge vessel for discharging the cooling water.

3. The descaling apparatus according to claim 2, wherein the water quality activating agent comprising:

a resin strip; and

fine-grained ceramic particles kneaded into the resin strip.

4. The descaling apparatus according to claim 1, wherein the electrostatic rectifier comprising:

a signal generation circuit for generating a decaying wave signal; and

an electrical wiring for applying the decaying wave signal generated by the signal generation circuit to the cooling water.

5. The descaling apparatus according to claim 4, wherein the decaying wave signal is a pulsed decaying wave signal repeating at a frequency of 20 kHz or higher and 60 kHz or lower.

6. A descaling system comprising:

a cooling tower containing cooling water;

a facility pipeline connected to the cooling tower and passing through a facility; and

a descaling apparatus provided in the cooling tower,

wherein the descaling apparatus comprising:

a circulation pipeline that transports cooling water contained in the cooling tower and returns the cooling water to the cooling tower; and

a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

7. The descaling system according to claim 6, wherein the water quality activator comprising:

a charge vessel that is charged with a water quality activating agent inside;

an introduction pipe for introducing the cooling water into the charge vessel; and

a discharge pipe connected to the charge vessel for discharging the cooling water.

8. The descaling system according to claim 6, wherein the electrostatic rectifier comprising:

a signal generation circuit for generating a decaying wave signal; and

an electrical wiring for applying the decaying wave signal generated by the signal generation circuit to the cooling water.

9. The descaling system according to claim 8, wherein the decaying wave signal is a pulsed decaying wave signal repeating at a frequency of 20 kHz or higher and 60 kHz or lower.

10. A descaling apparatus comprising:

a circulation pipeline; and

a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.

11. The descaling system comprising:

a facility pipeline passing through a facility; and

a descaling apparatus provided in the facility pipeline,

wherein the descaling apparatus comprising:

a circulation pipeline that transports water and returns the water to the facility pipeline; and

a pump, a water quality activator and an electrostatic rectifier provided in a path of the circulation pipeline.