

METHOD FOR CLEANING FURNACE WALL TUBE OF ONCE-THROUGH BOILER

TECHNICAL FIELD

[0001] The present disclosure relates to a method for cleaning a furnace wall tube of a
5 once-through boiler.

BACKGROUND ART

[0002] In a thermal power system in which oxygenated treatment is applied to a boiler
water-supply system, the metal temperature of a furnace wall tube of a once-through boiler
10 increases, and breakage of the furnace wall tube brings about leakage of boiler water. The
increase in the metal temperature of the furnace wall tube is caused by generation of hematite
(Fe_2O_3) due to dissolution of iron from piping of a low-pressure water supply heater drain
system or a water supply system, the hematite adhering and accumulating on the inner surface
of the furnace wall tube to deteriorate the thermal conductivity (hereinafter, hematite will be
15 referred to as a powder scale for its characteristics).

[0003] To prevent the leakage problem of a furnace wall tube, chemical cleaning is
performed regularly on a furnace wall tube to completely remove a scale composed of
ferrioxide accumulated on the inner tube surface.

[0004] For instance, Patent Document 1 discloses a chemical cleaning method which
20 includes an acid cleaning step of dissolving and removing a scale with acid (inorganic or
organic acid), a water cleaning step, and an anti-rust treatment step, performed in this order.
In the acid cleaning step, an acid solution is circulated through a boiler.

[0005] Further, for instance, Patent Document 2 discloses a method for cleaning a natural
circulation drum type boiler provided with an economizer, a furnace, and a heater. In this
25 cleaning method, a cleaning liquid containing an additive dispersive agent is injected into a
boiler including an economizer and a furnace but not a heater, from a cleaning system
temporarily provided for the boiler, and an inert gas is injected to perform bubbling while the
cleaning liquid is maintained in the boiler.

[0006] Further, for instance, Patent Document 3 discloses a method for discharging a powder scale, which includes a fluid filling step, a pressurizing step, and a pressure reducing step. In the fluid filling step, a space to be cleaned such as an evaporation pipe is filled with a cleaning fluid incorporating micro bubbles. In the pressurizing step, a predetermined time after the fluid filling step, the pressure of the cleaning fluid in a closed space is increased so as to compress the micro bubbles in the cleaning liquid to obtain relatively smaller micro bubbles and nano bubbles. In the pressure reducing step, the bubbles in the cleaning liquid, which are in a state of relatively smaller micro bubbles and nano bubbles from contraction in the pressurizing step, are expanded.

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Citation List

Patent Literature

[0007]

Patent Document 1: JP2012-24735A

15 Patent Document 2: JPH8-105602A

Patent Document 3: JP2014-142154A

SUMMARY

Problems to be Solved

20 [0008] The methods disclosed in Patent Documents 1 to 3 require a long time to clean the inner tube surface of the furnace wall tube, thus increasing the costs and time for construction.

[0009] In view of the above, an object of at least one embodiment of the present invention is to provide a method for cleaning a furnace wall tube of a once-through boiler whereby it is possible to reduce the cleaning time.

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Solution to the Problems

[0010] (1) A method for cleaning a furnace wall tube of a once-through boiler in a water supply system to which oxygenated treatment is applied, according to at least one

embodiment of the present invention, comprises: selectively removing, from among a self-oxidation scale and a powder scale formed on an inner surface of the furnace wall tube, the powder scale having a smaller thermal conductivity than the self-oxidation scale, by chemical cleaning.

5 [0011] As a result of researches by the present inventors, it was found that, since the cleaning methods disclosed in Patent Documents 1 and 2 remove an entire scale formed on the inner surface of a furnace wall tube, cleaning takes a long time, which may increase the construction costs and time, and also may cause damage to the inner surface of the furnace wall tube. Furthermore, the cleaning method disclosed in the Patent Documents uses pure
10 water containing micro bubbles as the cleaning fluid, increasing the pressure of the cleaning fluid from a normal pressure and then reducing the increased temperature, which makes it difficult to perform efficient cleaning.

[0012] In this regard, according to the above method (1), the method selectively removes the powder scale having a lower thermal conductivity than the self-oxidation scale by
15 chemical cleaning, from among the self-oxidation scale and the powder scale formed on the inner surface of the furnace wall tube, and thereby it is possible to reduce the cleaning time compared to a typical case in which all of the self-oxidation scale and the powder scale are removed. Further, since the self-oxidation scale is not removed, the cleaning liquid no longer damages the inner surface of the furnace wall tube.

20 [0013] (2) In some embodiments, the above method (1) comprises a cleaning test step of obtaining a cleaning condition of the chemical cleaning for selectively removing the powder scale; and a cleaning step of selectively removing the powder scale under the cleaning condition obtained in the cleaning test step.

[0014] As a result of researches by the present inventors, it was found that, while acid
25 cleaning and chelate cleaning are effective in chemical cleaning, for instance, cleaning for a long time at a high temperature with a cleaning liquid of a high concentration may cause partial damage to the self-oxidation scale due to the excessively high cleaning performance, thus resulting in a limited thermal conductivity due to separation of the self-oxidation scale,

as well as corrosion due to cleaning liquid remaining in the separated portion of the self-oxidation scale.

[0015] According to the above method (2), a chemical cleaning condition for selectively removing the powder scale is obtained, and the powder scale is selectively removed under the
5 obtained cleaning condition. Thus, it is possible to selectively remove the powder scale having a lower thermal conductivity than the self-oxidation scale, from among the self-oxidation scale and the powder scale.

[0016] (3) In some embodiments, in the above method (2), the cleaning condition includes at least one of a cleaning-liquid composition condition, a cleaning-liquid
10 concentration condition, a cleaning temperature condition, or a cleaning time condition.

[0017] According to the above method (3), the cleaning condition includes at least one of the cleaning-liquid composition condition, the cleaning-liquid concentration condition, the cleaning temperature condition, or the cleaning time condition, and thus it is possible to remove the powder scale having a lower thermal conductivity than self-oxidation scale under
15 an appropriate cleaning condition.

[0018] (4) In some embodiments, in the above method (2) or (3), the cleaning test step includes chemically cleaning a tester including a part of the furnace wall tube of the once-through boiler to be cleaned or a sample resembling the furnace wall tube, to obtain the cleaning condition under which the powder scale is selectively removable.

20 [0019] In the above method (4), a cleaning condition for selectively removing the powder scale is obtained by chemically cleaning the tester including a part of the furnace wall tube of the once-through boiler to be cleaned or a sample that resembles the furnace wall tube, and thereby it is possible to obtain a cleaning condition suitable for each of once-through boilers in different operational environments.

25 [0020] (5) In some embodiments, in the above method (4), the cleaning test step includes determining a completion timing of selective removal of the powder scale by monitoring a particle concentration in a cleaning liquid for chemical cleaning of the tester, and obtaining the cleaning condition on the basis of the completion timing.

[0021] According to the above method (5), the particle concentration in the cleaning liquid for chemical cleaning of the tester is monitored, and thereby a completion timing of the selective removal of the powder scale is determined to obtain a cleaning condition on the basis of the completion timing. Thus, it is possible to obtain the cleaning condition in a qualitative manner.

[0022] (6) In some embodiments, in the above method (5), in the cleaning test step, the completion timing is a timing when an increase rate of the particle concentration becomes less than a threshold.

[0023] According to the above method (6), the completion timing is the timing when the increase rate of the particle concentration becomes less than a threshold, and thereby it is possible to obtain the cleaning condition in a quantitative manner.

Advantageous Effects

[0024] According to at least one embodiment of the present invention, provided is a method for cleaning a furnace wall tube of a once-through boiler whereby it is possible to reduce the cleaning time.

BRIEF DESCRIPTION OF DRAWINGS

[0025] FIG. 1 is a conceptual diagram of a schematic configuration of a thermal power plant in which oxygenated treatment is applied to a boiler water supply system.

FIG. 2 is a conceptual diagram showing the thermal power plant depicted in FIG. 1 with a cleaning circulation path installed therein.

FIG. 3 is a schematic diagram of a furnace wall tube having a scale adhering and accumulating on its inner surface.

FIG. 4 is a diagram showing a relationship between the thickness and the metal temperature of a scale.

FIG. 5 is a diagram showing a relationship between the operation time of a once-through boiler and the thickness of a self-oxidation scale.

FIG. 6 is a conceptual diagram of an estimated structure of a furnace wall tube of a once-through boiler with a self-oxidation scale and a powder scale produced on the inner surface.

FIG. 7 is a table of cleaning conditions for selectively removing a powder scale.

5 FIG. 8 is a schematic conceptual diagram of a cleaning test device for obtaining a cleaning condition for selectively removing a powder scale.

FIG. 9 is a diagram showing a relationship between the cleaning time and the particle concentration and the increase rate of the particle concentration in a cleaning liquid.

10 DETAILED DESCRIPTION

[0026] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, shapes, relative positions and the like of components described in the embodiments shall be interpreted as illustrative only and not intended to limit
15 the scope of the present invention.

[0027] For instance, an expression of relative or absolute arrangement such as “in a direction”, “along a direction”, “parallel”, “orthogonal”, “centered”, “concentric” and “coaxial” shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an
20 angle or a distance whereby it is possible to achieve the same function.

[0028] Further, for instance, an expression of a shape such as a rectangular shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

25 [0029] On the other hand, an expression such as “comprise”, “include”, “have”, “contain” and “constitute” are not intended to be exclusive of other components.

[0030] FIG. 1 is a conceptual diagram of a schematic configuration of a thermal power plant 1 in which oxygenated treatment is applied to a boiler water supply system.

[0031] A method for cleaning a furnace wall tube 5 of a once-through boiler according to at least one embodiment of the present invention is a method for cleaning a furnace wall tube 5 of a once-through boiler in which oxygenated treatment is applied to a water supply system.

[0032] As depicted in FIG. 1, a thermal power plant 1 in which oxygenated treatment is applied to a boiler water supply system includes a turbine condenser 11, a condensate pump 12, a condensate treatment device 13, a condensate pressurizing pump 14, a low-pressure water supply heater 15, a deaerator 16, a boiler water supply pump 17, a high-pressure water supply heater 18, a furnace economizer 19, a super heater 20, and a re-heater 21. Further, the furnace economizer 19 includes an economizer 22, a furnace 23, a gas-liquid separator 24, a gas-liquid separation tank 25, and a boiler circulation pump 26.

[0033] FIG. 2 is a conceptual diagram showing the thermal power plant 1 depicted in FIG. 1 with a cleaning circulation path 3 installed therein.

[0034] As depicted in FIG. 2, the cleaning circulation path 3 circulates a cleaning liquid between the economizer 22 and the gas-liquid separator 24, and cleans and removes a scale S (see FIG. 3) adhering and accumulating on the inner surface of the furnace wall tube 5. The cleaning circulation path 3 includes a buffer tank 31, a circulation pump 32, a heater 33, and a waste fluid tank 34, which are connected to one another through a temporary pipe 35.

[0035] The buffer tank 31 stores a cleaning liquid, and the cleaning liquid stored in the buffer tank 31 is sent out by the circulation pump 32. The cleaning liquid sent out by the circulation pump 32 is heated by the heater 33, and flows through the economizer 22, the furnace 23, and the gas-liquid separator 24, to be recovered by the buffer tank 31. Accordingly, the cleaning liquid stored in the buffer tank 31 circulates between the economizer 22 and the gas-liquid separator 24, and cleans and removes the scale S adhering and accumulating on the inner surface of the furnace wall tube 5 (chemical cleaning).

[0036] FIG. 3 is a schematic diagram of the furnace wall tube 5 having the scale S adhering and accumulating on its inner surface.

[0037] As depicted in FIG. 3, the scale S adhering and accumulating on the inner surface of the furnace wall tube 5 includes a self-oxidation scale HS and a powder scale PS. The

self-oxidation scale HS accumulates to form a thin layer on the inner surface of the furnace wall tube 5, and the powder scale PS has a porous structure of a small particle diameter and adheres to the surface of the self-oxidation scale HS.

[0038] FIG. 4 is a diagram showing a relationship between the thickness and the metal temperature of the scale S.

[0039] As depicted in FIG. 4, an increase in the metal temperature is affected more by the thickness of the powder scale PS and less by the thickness of the self-oxidation scale HS. Further, while the metal temperature of the furnace wall tube 5 is controlled to be at or under a control temperature, the metal temperature of the furnace wall tube 5 does not reach the control temperature unless the self-oxidation scale HS develops to have a thickness of a predetermined value (hereinafter, referred to as “HS thickness limit value”).

[0040] FIG. 5 is a diagram showing a relationship between the operation time of the once-through boiler and the thickness of the self-oxidation scale HS.

[0041] As depicted in FIG. 5, the development rate of the self-oxidation scale HS is relatively slow, and the thickness does not reach the HS thickness limit value even after 10 years or so. Accordingly, even if the self-oxidation scale HS is not removed, the metal temperature of the furnace wall tube 5 does not reach the control temperature in about 10 years.

[0042] In contrast, the powder scale PS has a smaller thermal conductivity than the self-oxidation scale HS, and the metal temperature of the furnace wall tube 5 reaches the control temperature when the thickness of the powder scale PS increases to a predetermined value (hereinafter, referred to as “PS thickness control value”), and it is necessary to maintain the thickness of the powder scale PS to be not greater than the PS thickness control value.

[0043] Further, the powder scale PS is brought in by boiler supply water to adhere and develop, depending on the water quality of the supply water. Thus, depending on the water quality of the supply water, the furnace wall tube 5 may reach the control temperature in either two or ten years, for instance.

[0044] In view of this, a method for cleaning the furnace wall tube 5 of a once-through

boiler according to some embodiments selectively removes the powder scale PS having a lower thermal conductivity than the self-oxidation scale HS by chemical cleaning, from among the self-oxidation scale HS and the powder scale PS formed on the inner surface of the furnace wall tube 5.

5 [0045] In the embodiment illustrated in FIG. 2, the cleaning liquid is circulated until the powder scale PS having a lower thermal conductivity than the self-oxidation scale HS is selectively removed by chemical cleaning, from the scale S adhering and accumulating on the inner surface of the furnace wall tube 5.

[0046] The above described method for cleaning the furnace wall tube 5 of the once-through boiler according to some embodiments selectively removes the powder scale PS having a lower thermal conductivity than the self-oxidation scale HS by chemical cleaning, from among the self-oxidation scale HS and the powder scale PS formed on the inner surface of the furnace wall tube 5, and thereby it is possible to reduce the cleaning time compared to a typical case in which all of the self-oxidation scale HS and the powder scale PS are removed.
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15 Further, since the self-oxidation scale HS is not removed, the cleaning liquid no longer damages the inner surface of the furnace wall tube 5.

[0047] FIG. 6 is a conceptual diagram of an estimated structure of the furnace wall tube 5 of a once-through boiler with the self-oxidation scale HS and the powder scale PS generated on the inner surface.

20 [0048] The outer surface of the powder scale PS has a small sticking force, and can be partially removed by water washing. In contrast, in the vicinity of a boundary between the powder scale PS and the self-oxidation scale HS, the powder scale PS has such a sticking force that makes it difficult to remove the powder scale PS by water washing. This may be because, as depicted in FIG. 6, the powder scale PS binds with the powder scale PS, and the powder scale PS binds with the self-oxidation scale HS, via magnetite or the like serving as a binder B, and because the surface layer of the self-oxidation scale HS is rough on a micro level, so that the powder scale PS is physically held by the self-oxidation scale HS. Thus, to
25 selectively remove the powder scale PS, it is necessary to dissolve at least the surface layer of

the self-oxidation scale HS or the binder B.

[0049] Acid cleaning and chelate cleaning are effective, for instance, for such dissolution. However, cleaning for a long time at a high temperature with a cleaning liquid of a high concentration may cause partial damage to the self-oxidation scale HS due to an excessively high cleaning performance, thus resulting in a limited thermal conductivity due to separation of the self-oxidation scale HS, as well as corrosion due to cleaning liquid remaining at the separated part of the self-oxidation scale HS.

[0050] In view of this, a method for cleaning the furnace wall tube 5 of a once-through boiler according to some embodiments includes a cleaning test step and a cleaning step.

[0051] The cleaning test step is for obtaining a cleaning condition of chemical cleaning for selectively removing the powder scale PS, and the cleaning step is for selectively removing the powder scale PS under the cleaning condition obtained in the cleaning test step.

[0052] According to the above described method for cleaning the furnace wall tube 5 of a once-through boiler according to some embodiments, a chemical cleaning condition for selectively removing the powder scale PS is obtained, and the powder scale PS is selectively removed under the obtained cleaning condition. Thus, it is possible to selectively remove the powder scale PS having a lower thermal conductivity than the self-oxidation scale HS, from among the self-oxidation scale HS and the powder scale PS.

[0053] FIG. 7 is a table of cleaning conditions for selectively removing a powder scale.

As shown in FIG. 7, cleaning conditions according to some embodiments include at least one of a cleaning-liquid composition condition, a cleaning-liquid concentration condition, a cleaning temperature condition, or a cleaning time condition.

[0054] As shown in FIG. 7, in a representative chemical cleaning procedure for cleaning a furnace wall tube of a once-through boiler, the cleaning liquid is composed of an organic acid such as citric acid and hydroxy acid. The concentration of the cleaning liquid is from 3% to 10%, and the number of cleaning depends on the amount of scale S adhering to the inner surface of the furnace wall tube 5. Further, the temperature of the cleaning liquid is from 80°C to 90°C, and the cleaning time is from six to ten hours.

[0055] Although the representative chemical cleaning procedure is suitable for entirely removing the scale S adhering and accumulating on the inner surface of the furnace wall tube 5, it is not suitable for selectively removing the powder scale PS. Specifically, the representative chemical cleaning procedure removes not only the powder scale PS but also the self-oxidation scale HS.

[0056] Compared to this, in the first cleaning condition, the temperature of the cleaning liquid is reduced, while the composition of the cleaning liquid, the concentration of the cleaning liquid, and the cleaning time are the same as those in the above representative chemical cleaning procedure. The temperature of the cleaning liquid is normal temperature, for instance, and the cleaning liquid does not need to be heated in this case, which is an advantage. According to the first cleaning condition, damage to the self-oxidation scale HS is suppressed, and the powder scale PS can be selectively removed.

[0057] In the second cleaning condition, the cleaning time is reduced, while the composition of the cleaning liquid, the concentration of the cleaning liquid, and the temperature of the cleaning liquid are the same as those in the above representative chemical cleaning procedure. The cleaning time is one hour, for instance, and the cleaning can be completed in a shorter period of time in this case, which is an advantage. According to the second cleaning condition, damage to the self-oxidation scale HS is suppressed, and the powder scale PS can be selectively removed.

[0058] In the third cleaning condition, the concentration of the cleaning liquid is reduced, while the composition of the cleaning liquid, the temperature of the cleaning liquid, and the cleaning time are the same as those in the above representative chemical cleaning procedure. The concentration of the cleaning liquid is less than 3%, for instance, and a smaller amount of cleaning liquid (undiluted solution) is needed in this case, which is an advantage. According to the third cleaning condition, damage to the self-oxidation scale HS is suppressed, and the powder scale PS can be selectively removed.

[0059] In the fourth cleaning condition, the above described representative chemical cleaning procedure is changed with some options. The cleaning liquid is composed of an

organic acid such as EDTA, malonic acid, and hydroxyacetic acid. The concentration of the cleaning liquid is from 3% to 10%, or less than 3%, and the number of cleaning is normally more than once, though depending on the amount of the scale S adhering to the inner surface of the furnace wall tube 5. Further, the temperature of the cleaning liquid is from 80°C to 90°C, or normal temperature, and the cleaning time is from six to ten hours, or less than one hour. According to the fourth cleaning condition, damage to the self-oxidation scale HS is suppressed, and the powder scale PS can be selectively removed.

[0060] The above described cleaning conditions according to some embodiments include at least one of the cleaning-liquid composition condition, the cleaning-liquid concentration condition, the cleaning temperature condition, or the cleaning time condition, and thus it is possible to selectively remove the powder scale P having a lower thermal conductivity than the self-oxidation scale HS, under an appropriate cleaning condition.

[0061] FIG. 8 is a conceptual diagram of a cleaning test device for obtaining a cleaning condition for selectively removing powder scale PS.

[0062] As the cleaning liquid for selectively removing the powder scale PS, at least one of an inorganic acid (hydrochloric acid), an organic acid (citric acid, malonic acid, or hydroxyacetic acid), or a chelate agent can be used.

[0063] It is desirable to maintain the soundness of the self-oxidation scale HS by ending the cleaning when the binder or the holder of the powder scale PS is dissolved, or when the powder scale PS is separated.

[0064] However, the time required to dissolve the powder scale PS or to separate the powder scale PS varies depending on the cleaning-liquid composition condition, the cleaning temperature condition, and the adhering condition of the powder scale PS.

[0065] In the cleaning test step according to some embodiments, a cleaning condition under which the powder scale PS can be selectively removed is obtained by chemically cleaning a tester TP including a part of the furnace wall tube 5 of the once-through boiler to be cleaned or a sample that resembles the furnace wall tube 5.

[0066] In the embodiment depicted in FIG. 7, a scale dissolution test device 6 is used to

test a tester TP that constitutes a part of the furnace wall tube 5 of the once-through boiler to be cleaned. The scale dissolution test device 6 includes a temperature-control vessel 61, a circulation pump 62, a circulation tank 63, and a particle counter 64. The tester TP is immersed in the temperature-control vessel 61, and the cleaning liquid stored in the circulation tank 63 is sent out by the circulation pump 62. The cleaning liquid sent out by the circulation pump 62 flows through the tester TP, and is recovered by the circulation tank 63. Accordingly, the cleaning liquid stored in the circulation tank 63 circulates the tester TP, and cleans the scale S (powder scale PS) adhering to the inner surface of the tester TP.

[0067] In the above described cleaning test step according to some embodiments, a cleaning condition under which the powder scale PS can be selectively removed is obtained by chemically cleaning the tester TP including a part of the furnace wall tube 5 of the once-through boiler to be cleaned or a sample that resembles the furnace wall tube, and thereby it is possible to obtain a cleaning condition suitable for each of once-through boilers that operate in different environments.

[0068] FIG. 9 is a diagram showing a relationship between the cleaning time and the particle concentration and the increase rate of the particle concentration in a cleaning liquid. The relationship shown in FIG. 9 is merely an example.

[0069] A powder scale is a ferrioxide called hematite (Fe_2O_3) which is less soluble than the self-oxidation scale HS. Thus, a powder scale cannot be fully dissolved even by chemical cleaning, and the particles of the powder scale become suspended in the cleaning liquid or accumulate in an accumulating section. Further, as the cleaning time becomes longer, the particles suspended in the cleaning liquid increase in number and eventually accumulate at the accumulating section.

[0070] Thus, in the cleaning test step according to some embodiments, the particle concentration in the cleaning liquid for chemical cleaning of the tester TP is monitored, and the completion timing of the selective removal of the powder scale PS is determined to obtain the cleaning condition on the basis of the completion timing.

[0071] In the embodiment depicted in FIG. 8, a particle counter 64 is used to monitor the

particle concentration, and thereby the completion timing of the selective removal of the powder scale PS is determined to obtain the cleaning time on the basis of the completion timing. The particle counter 64 monitors particles having a particle diameter of a predetermined value (e.g. 10 μ m), and thereby eliminates interference of a foreign substance or separation sludge from the self-oxidation scale HS, for instance.

[0072] The particle concentration is the number of particles in the cleaning liquid, and the increase rate of the particle concentration can be obtained by {(the number of particles after n hours)-(the number of particles after n hours)}/ (the number of particles after n hours)*100.

[0073] As shown in FIG. 9, the particle concentration normally increases and the increase rate of the particle concentration decreases as the cleaning time gets longer. Thus, by monitoring the particle concentration and the increase rate of the particle concentration, the completion timing of the selective removal of the powder scale PS is determined, and the cleaning condition (cleaning time) is obtained on the basis of the completion timing.

[0074] According to the cleaning test step of some embodiments, the particle concentration in the cleaning liquid used for chemical cleaning of the tester TP is monitored, and thereby the completion timing of the selective removal of the powder scale PS is determined to obtain the cleaning condition on the basis of the completion timing. Thus, it is possible to obtain the cleaning condition a qualitative manner.

[0075] In the cleaning test step according to some embodiments, the completion timing is the timing when the increase rate of the particle concentration becomes less than a threshold.

[0076] In the embodiment depicted in FIG. 9, the threshold is 10%/hour, and the completion timing is the timing when the increase rate of the particle concentration becomes less than 10%/hour.

[0077] In the cleaning test step according to some embodiments, the completion timing is the timing when the increase rate of the particle concentration becomes less than a threshold, and thereby it is possible to obtain the cleaning condition in a quantitative manner.

[0078] While the particle concentration is monitored by using the particle counter 64 in the embodiment depicted in FIG. 8, the particle concentration may be monitored by a

simplified monitoring method used in construction or startup of a plant. Specifically, a membrane filter may be used to filter sample water, and then the concentration of iron may be estimated from the color of the filter. In this case, the completion timing is the timing when an increase in the particle concentration contained in the cleaning liquid can no longer be confirmed.

[0079] Embodiments of the present invention were described in detail above, but the present invention is not limited thereto, and various amendments and modifications may be implemented.

10 Description of Reference Numerals

[0080]

- 1 Thermal power plant
- 11 Turbine condenser
- 12 Condensate pump
- 15 13 Condensate treatment device
- 14 Condensate pressurizing pump
- 15 Low-pressure water supply heater
- 16 Deaerator
- 17 Boiler water supply pump
- 20 18 High-pressure water supply heater
- 19 Furnace economizer
- 20 Super heater
- 21 Re-heater
- 22 Economizer
- 25 23 Furnace
- 24 Gas-liquid separator
- 25 Gas-liquid separation tank
- 26 Boiler circulation pump

	3	Cleaning circulation path
	31	Buffer tank
	32	Circulation pump
	33	Heater
5	34	Waste fluid tank
	35	Temporary pipe
	5	Furnace wall tube
	6	Scale dissolution test device
	61	Temperature-control vessel
10	62	Circulation pump
	63	Circulation tank
	64	Particle counter
	S	Scale
	HS	Self-oxidation scale
15	PS	powder scale
	B	Binder
	TP	Tester

CLAIMS

1. A method for cleaning a furnace wall tube of a once-through boiler in a water supply system to which oxygenated treatment is applied, the method comprising:

5 selectively removing, from among a self-oxidation scale and a powder scale formed on an inner surface of the furnace wall tube, the powder scale having a smaller thermal conductivity than the self-oxidation scale, by chemical cleaning.

2. The method for cleaning a furnace wall tube of a once-through boiler according to claim 1, comprising:

10 a cleaning test step of obtaining a cleaning condition of the chemical cleaning for selectively removing the powder scale; and

a cleaning step of selectively removing the powder scale under the cleaning condition obtained in the cleaning test step.

15 3. The method for cleaning a furnace wall tube of a once-through boiler according to claim 2, wherein the cleaning condition includes at least one of a cleaning-liquid composition condition, a cleaning-liquid concentration condition, a cleaning temperature condition, or a cleaning time condition.

20 4. The method for cleaning a furnace wall tube of a once-through boiler according to claim 2 or 3, wherein the cleaning test step includes chemically cleaning a tester including a part of the furnace wall tube of the once-through boiler to be cleaned or a sample resembling the furnace wall tube, to obtain the cleaning condition under which the powder scale is selectively
25 removable.

5. The method for cleaning a furnace wall tube of a once-through boiler according to claim 4, wherein the cleaning test step includes determining a completion timing of selective

removal of the powder scale by monitoring a particle concentration in a cleaning liquid for chemical cleaning of the tester, and obtaining the cleaning condition on the basis of the completion timing.

- 5 6. The method for cleaning a furnace wall tube of a once-through boiler according to claim 5, wherein, in the cleaning test step, the completion timing is a timing when an increase rate of the particle concentration becomes less than a threshold.