

SPECIFICATION

WATER TREATMENT METHOD FOR BOILER HAVING ECONOMIZER

TECHNICAL FIELD

[0001]

The present invention relates to a method for treating water of a boiler having an economizer which is made of a carbon steel in a part or an entire part thereof, and in more detail to a method to prevent scaling in a boiler vessel and to effectively suppress generation of corrosion in an economizer by controlling P-alkalinity and silica concentration in a supply water within specific ranges.

BACKGROUND ART

[0002]

In the past, there have been pointed out three major reasons for causing corrosion in a boiler system, namely, a supply water to a boiler or a vessel water has: (1) high concentration of a dissolved oxygen, (2) a pH outside a proper range, and (3) high concentrations of harmful ions such as a chloride ion and a sulfate ion.

Accordingly, as the method to prevent corrosion on the water side of the vessel in a boiler water system, there has been generally used such a method as the one in which an agent is injected into the system thereby controlling a pH within a proper range, removing a dissolved oxygen, and forming an anticorrosive film on a steel surface. In this process, the said agent is injected with considering concentration in the vessel, so that both the pH and the concentration of the agent are low in a non-concentrated part thereof, whereby formation of the anticorrosive film is insufficient.

An economizer of a boiler is generally a non-concentrated part so that both the pH and the concentration of the agent, even if it is added thereto, are low whereby formation of the anticorrosive film may be insufficient. Moreover, inside the economizer, in spite of high temperature of water, concentration of a dissolved oxygen is so high that the environment therein is highly corrosive thereby causing many problems. Especially, frequency of the problem associated with a pin hole due to corrosion is so high in an economizer made of carbon steel for a low pressure boiler; and thus, in certain instances a pin hole is formed within 2 to 3 years since the time of its installation.

[0003]

As to the anticorrosion technologies for the economizer, the anticorrosion technology by an agent and the anticorrosion technology by deoxygenating equipment are known.

In the anticorrosion technology by an agent, the agent is charged in the upstream of the economizer to control a pH thereby forming an anticorrosive film and the like on surface of the steel material. In this process, if an agent having the concentration high enough to prevent corrosion of the economizer is added, in a concentrated part of a boiler vessel, the pH and the electric conductivity may become so high that a carry-over and an alkaline corrosion tend to occur readily. On the other hand, by considering that it is concentrated in the boiler vessel, if the agent with low concentration is charged, low pH and low concentration of the agents may occur in a non-concentrated part of the water supply tube, the economizer, and the like whereby formation of the anticorrosive film may be insufficient, which may result in corrosion.

[0004]

In Patent Document 1, a method for preventing corrosion and pitting of a boiler, wherein tartaric acid or a salt thereof, citric acid or a salt thereof, and an alkaline agent in an amount to make pH of the supply water to a boiler within the range of 8 to 12 are added in the supply water to a boiler, is disclosed.

In Patent Document 2, a method for preventing corrosion of a boiler system, wherein an anticorrosive film is formed by injecting a silicate salt to the supply water to a boiler, is disclosed.

On the other hand, in the case of the corrosion preventing method by using a deoxygenating equipment such as the one with a nitrogen-displacing type, a deoxygenating equipment having a function capable of removing oxygen to the concentration level low enough to be able to prevent corrosion of the economizer from occurring is so large that it may often require large investment for such an equipment whereby inevitably narrowing its utility range.

[0005]

Patent Document 1: Japanese Patent Laid-Open Publication No. 2005-220396

Patent Document 2: Japanese Patent Laid-Open Publication No. 2001-336701

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

In the art described in Patent Document 1, a method to add tartaric acid, citric acid, and an alkaline agent into water to be supplied to a boiler is disclosed. However, the laboratory evaluation of Test Example 1 described therein simulates only the continuous flow condition; and thus, it is unclear that the corrosion suppression effect of this method on the economizer under the actual operation condition of the boiler in which the operation of flow and stop is repeated by on/off switching of a water supplying pump.

On the other hand, in the art described in Patent Document 2, the evaluations were made only in the boiler vessel; and no investigation was carried out as to the effect on the economizer, which is a non-concentrated part where temperature condition, water quality condition such as pH, and the like are quite different from those of the boiler vessel.

[0007]

The present invention was made under the situation as mentioned above, and has an object to provide a method for treating water of a boiler having an economizer, wherein a corrosion suppression effect is expressed in non-concentrated parts such as a water supplying tube and an economizer, and also scaling in a concentrated part such as a boiler vessel can be prevented.

MEANS FOR SOLVING THE PROBLEMS

[0008]

Inventors of the present invention carried out an extensive investigation to achieve the object mentioned above; and as a result, it was found that this object could be achieved by adding an alkaline ingredient and a silica ingredient to a supply water charged into an economizer in such a way that P-alkalinity (mg-CaCO₃/L) and silica concentration (mg-SiO₂/L) of the said supply water may become specific values respectively. The present invention was completed based on this finding.

[0009]

That is, the present invention provides the followings.

(1) A method for treating water of a boiler having an economizer made of a carbon steel in a part or an entire part thereof comprising,

adding an alkaline ingredient and a silica ingredient to a supply water charged into the economizer in such a way that P-alkalinity of the supply water may become in the range of 20 to 100 mg-CaCO₃/L and silica concentration of the same may become in the range of 10

to 100 mg-SiO₂/L.

- (2) The method for treating water of a boiler having an economizer according to (1), wherein the alkaline ingredient and the silica ingredient are added in such a way that ratio of P-alkalinity/silica concentration in boiler water may become 1.0 or more.
- (3) The method for treating water of a boiler having an economizer according to (1) or (2), wherein the alkaline ingredient is an alkaline hydroxide.
- (4) The method for treating water of a boiler having an economizer according to any of (1) to (3), wherein the silica ingredient is a silicate salt.
- (5) The method for treating water of a boiler having an economizer according to any of (1) to (4), wherein an anti-scaling agent is further added to the supply water.
- (6) The method for treating water of a boiler having an economizer according to (5), wherein the anti-scaling agent is an acrylate polymer.
- (7) The method for treating water of a boiler having an economizer according to (6), wherein the acrylate polymer is a polyacrylate salt having number-average molecular weight of 20,000 to 70,000.
- (8) The method for treating water of a boiler having an economizer according to any of (1) to (7), wherein a water supplying pump is comprised a water supplying line, and the water supplying pump is performable an ON/OFF operation in accordance with a water level in the boiler whereby supplying the supply water intermittently.
- (9) The method for treating water of a boiler having an economizer according to any of (1) to (8), wherein the boiler to be used herein is a space-saving once-through boiler.
- (10) The method for treating water of a boiler having an economizer according to any of (1) to (9), wherein the alkaline ingredient and the silica ingredient are added to a water supplying system with which water is supplied to the economizer.

EFFECT OF THE INVENTION

[0010]

According to the present invention, by adding an alkaline ingredient and a silica ingredient to the supply water charged into an economizer in such a way that P-alkalinity and silica concentration of the said supply water may be maintained at the specific values respectively, a corrosion suppression can be effectively expressed in non-concentrated parts such as a water supplying tube and the economizer, and also scaling in a concentrated part such as a boiler vessel can be prevented.

BRIEF DESCRIPTION OF DRAWING

[0011]

FIG. 1 shows a rough diagram of the test equipment which simulates the economizer used in Test Examples.

MODE FOR CARRYING OUT THE INVENTION

[0012]

Water treatment method:

In the method for treating water of a boiler having an economizer in the present invention (hereinafter sometimes refer to simply “water treatment method for a boiler of the present invention” or “water treatment method of the present invention”), an alkaline ingredient and a silica ingredient are added to the supply water charged into the economizer in such a way that the P-alkalinity of the said supply water may become in the range of 20 to 100 mg-CaCO₃/L and the silica concentration of the same may become in the range of 10 to 100 mg-SiO₂/L.

[0013]

The boiler used in the water treatment method of the present invention is made of carbon steel at least in a part or an entire part of the economizer. For example, preferably at least a part of the economizer to which the supply water contact is made of carbon steel.

The water supplying system to be used in the water treatment method of the present invention is a boiler water system, wherein any of pure supply water, a reverse osmosis (RO) supply water, and softened supply water may be used as the supply water.

[0014]

A type of the boiler is not particularly limited; and thus, any type may be used provided that it is provided with an economizer made of carbon steel that is used in heating the supply water to the boiler by utilizing the heat of the gas exhausted from the boiler. Therefore, a space-saving once-through boiler, a water tube boiler, a cylindrical boiler, an exhaust heat recovery boiler, and so forth may be used; however, a space-saving once-through boiler in which the operation of flow and stop is repeated many times by the on/off switch of a water supplying pump is preferably used.

The space-saving once-through boiler of the present invention means a specialty circulating boiler that is specified in JIS B8223. That is, this is a water tube boiler mainly comprising tubes, wherein water is charged from one its end, and a mixture of steam and

water is injected from its other end, and after steam and water are separated in a steam-water separator, hot water returns to the heating tubes with the amount thereof being 50% or less relative to the mixture of steam and water. The supply water to the space-saving once-through boiler is generally regulated by the water supply system with the ON/OFF switch of the water supplying pump; and thus, inside the heat transfer tubes of the economizer installed in the space-saving once-through boiler is under the condition of repeating operation of flow and stop of the water supply. Especially under the condition like this, corrosion tends to readily occur inside the economizer; however, according to the water treatment method of the present invention, this corrosion can be suppressed.

There is no limitation as to the pressure applied to the boiler. However, if the pressure is too high, thermal decomposition of an anticorrosive agent and so forth added therein tends to occur readily; and thus, the method is used preferably under the pressure of preferably 3.0 MPa or lower, or more preferably 2.0 MPa or lower.

[0015]

Next, the water treatment method for a boiler having an economizer in the present invention will be explained specifically.

Below, one example of the boilers usable in the water treatment method of the present invention will be shown.

The boiler used in the water treatment method of the present invention has an economizer in the upstream of the water supplying system, and a boiler main body having a boiler vessel in the downstream thereof. Water that is supplied to the economizer is heated by a heat exchanger in the economizer by utilizing the exhausted heat from the boiler.

The boiler used in the present invention is equipped with a water supplying pump with which water is supplied to the economizer.

The water supply pump may be operated by the ON/OFF switch in accordance with the water level in the boiler vessel, so that water may be supplied intermittently.

[0016]

Alkaline ingredient:

In the present invention, an alkaline ingredient is added to the supply water supplied to the economizer in such a way that it may bring the P-alkalinity in the supply water to the range of 20 to 100 mg-CaCO₃/L.

The "P-alkalinity" is the value (mg/L as CaCO₃) which is the amount of calcium carbonate (CaCO₃) present per one liter of the sample, wherein this amount is obtained by

converting from the amount (mg) of an acid (either hydrochloric acid or sulfuric acid) necessary to bring one liter sample to the pH of 8.3 by neutralizing with the said acid the alkaline components dissolved in water, such as hydrogen carbonate salts, carbonate salts, phosphate salts, and hydroxides. Here, the supply water means the supply water which is obtained after mixing with agents at the inlet port of the economizer. In the present invention, the above-mentioned concentration may be obtained by the method described in EXAMPLES.

[0017]

If the P-alkalinity in the supply water is below 20 mg- CaCO_3/L , the anticorrosive effect in the economizer is insufficient; on the other hand, if the P-alkalinity is over 100 mg- CaCO_3/L , the electric conductivity thereof becomes too high, and the carry-over tends to readily occur in the boiler vessel in the later stage. Moreover, in order to prevent the carry-over, if the blow amount is increased, then this would cause energy loss, and thus it would be uneconomical.

From the above view point, the alkaline ingredient is added in the water supplying line in such a way that it may bring the P-alkalinity in the supply water preferably within the range of 30 to 90 mg- CaCO_3/L , or more preferably within the range of 40 to 80 mg- CaCO_3/L .

Illustrative example of the alkaline ingredient that is usable to adjust the P-alkalinity in the present invention includes alkaline hydroxides such as NaOH, KOH, and LiOH, as well as sodium silicate (this is dissolved in the supply water to generate NaOH). These alkaline ingredients may be used singly or as a mixture of two or more of them.

[0018]

Silica ingredient:

In the water treatment method for a boiler having an economizer in the present invention a silica ingredient is added to the supply water charged into the economizer in such a way that the silica concentration of the said supply water may become in the range of 10 to 100 mg- SiO_2/L .

The “silica concentration” means the concentration which is the converted value of SiO_2 from ionic components derived from the silicon atom per one liter of the sample. In the present invention, the silica concentration may be obtained by the method described in EXAMPLES.

[0019]

If the silica concentration in the supply water is less than 10 mg- SiO_2/L , the

anticorrosive effect in the economizer is insufficient; on the other hand, if the concentration thereof is more than 100 mg-SiO₂/L, silica forms a scale in the boiler vessel in the later stage, thereby leading to undesirable situation. Moreover, in order to prevent the scaling, degree of concentration needs to be lowered so that the blow amount needs to be increased, which would cause energy loss, and thus it would be uneconomical.

From the above view point, the silica ingredient is added in the water supplying line in such a way that it may bring the silica concentration in the supply water preferably within the range of 10 to 70 mg- SiO₂/L, or more preferably within the range of 10 to 60 mg- SiO₂/L.

Illustrative example of the silica ingredient that is usable includes silicic acid and silicate salts, such as sodium silicate and calcium silicate.

[0020]

In the water treatment method for a boiler having an economizer in the present invention, in order to prevent generation of the silica scale at high temperature in the boiler vessel, it is preferable to add an alkaline ingredient and a silica ingredient in such a way that the ratio of P-alkalinity/silica concentration in the boiler water may become 1.0 or more. If the ratio of P-alkalinity/silica is 1.0 or more, deposition of silica can be prevented so that the preventive effect of scaling may be expressed more eminently. The ratio of P-alkalinity/silica in the boiler water may be obtained by the method described in EXAMPLES.

Meanwhile, the P-alkalinity in the boiler water is influenced by alkaline components derived from the agents that are added in the water supplying line as well as those derived from alkaline components that are generated when the hydrogen carbonate ion and so forth contained in the original water are decomposed in the boiler.

[0021]

Anti-scaling agent:

In order to prevent scaling due to hard water and silica components in the boiler vessel if hardness leakage happens to take place, it is preferable to use an anti-scaling agent together with the alkaline agent and the silica ingredient.

As to the anti-scaling agent, it is preferable to add an acrylate polymer, carboxymethyl cellulose, salts of them, and the like, especially, more preferably a polyacrylate salt, or still more preferably a polyacrylate salt having the number-average molecular weight within the range of 20,000 to 70,000. There is no particular limitation as to the adding amount of the polyacrylate salt into the supply water; but it is added in such a way that concentration thereof in the supply water may become usually in the range of about

0.1 to 100 mg/L, or preferably in the range of 1 to 50 mg/L. Meanwhile, the number-average molecular weight of the polyacrylate salt is the converted value obtained by a gel permeation chromatography (GPC) to the standard polystyrene.

With this, even if a hard component is mixed into the supply water due to hardness leakage and the like, a scaling inside the boiler vessel may be prevented.

[0022]

Other additives:

In the water treatment method for a boiler having an economizer in the present invention, other additives, such as those existing additives as a deoxygenating agent, an anticorrosive agent, and a neutral amine, may be used concurrently. These other additives may be mixed arbitrarily, provided that such mixing may not inversely affect the object of the present invention, and thereafter this mixture may be added into the boiler water system (supply water), or these may be added separately into the boiler water system and then mixed therein.

[0023]

(Deoxygenating agent)

Illustrative example of the deoxygenating agent includes hydrazine, carbohydrazide, 1-aminopyrrolidine, 1-amino-4-methylpiperazine, N,N-diethyl hydroxylamine, tannin (tannic acid) or its salt, erythorbic acid or its salt, and ascorbic acid or its salt.

These deoxygenating agents may be used solely or as a combination of two or more of them.

Alternatively, deoxygenating equipment, such as a nitrogen-displacing type, a membrane type, and a vacuum type, may be used concurrently.

[0024]

(Anticorrosive agent)

There is no particular limitation as to the anticorrosive agent, and illustrative example thereof includes citric acid, isocitric acid, gluconic acid, glycolic acid, tartaric acid, erythorbic acid, malic acid, lactic acid, ascorbic acid, 2-phosphonobutane-1,2,4-tricarboxylic acid (PBTC), hydroxyphosphonoacetic acid (HPAC), and their salts.

These anticorrosive agents may be used solely or as a combination of two or more of them.

As to the above-mentioned salts, alkaline metal salts, such as sodium salts and potassium salts, and ammonium salts may be included.

[0025]

(Neutral amine)

Illustrative example of the neutral amine usable includes monoethanol amine (MEA), cyclohexylamine (CHA), morpholine (MOR), diethylethanol amine (DEEA), monoisopropanol amine (MIPA), 3-methoxypropyl amine (MOPA), and 2-amino-2-methyl-1-propanol (AMP).

These neutral amines may be used solely or as a combination of two or more of them.

[0026]

According to the water treatment method for a boiler having an economizer of the present invention, by bringing the P-alkalinity and the silica concentration in the supply water within specific respective ranges, a scaling in the boiler vessel may be prevented, and also corrosion in the economizer may be effectively suppressed.

According to the water treatment of the present invention, even in the experimental boiler in which the operation of flow and stop is repeated by action of the ON/OFF switch of the water supplying pump, corrosion can be suppressed more than ever in such places as the water supplying tube and the non-concentrated part of the economizer which is made of a carbon steel; and as a result, this contributes to the stable operation and elongation of the life of the boiler equipment.

EXAMPLES

[0027]

Next, the present invention will be explained in more detail by Examples; but the present invention is not limited at all by these Examples.

[0028]

(P-alkalinity in the supply water)

The P-alkalinity in the supply water was obtained as the calculated value from the P-alkalinity generated from the alkaline ingredient (for example sodium hydroxide) and the silica ingredient (for example, #3 sodium silicate) which were added in the upstream of the economizer.

For example, 1.25 mg of CaCO_3/L is generated as the P-alkalinity from 1 mg/L of NaOH, and 0.153 mg/L of CaCO_3/L is generated as the P-alkalinity from 1 mg/L of #3 sodium silicate.

[0029]

(Silica concentration in the supply water)

The silica concentration in the supply water was obtained as the calculated value obtained by summing up of the silica concentration in the original water as measured according to the analysis method for an ionic silica depicted in JIS B8224:2005 and the silica concentration generated from the added alkaline ingredient (for example #3 sodium silicate).

Meanwhile, in Test Example 1-2, the silica concentration in the original water was negligibly so low that the silica concentration in the supply water was the calculated value generated from the alkaline ingredient (for example #3 sodium silicate).

[0030]

(Ratio of P-alkalinity/silica concentration in the boiler water)

The P-alkalinity in the boiler water was the measured value obtained in accordance with the measurement method described in JIS B8224:2005.

The silica concentration in the boiler water was the measured value obtained in accordance with the measurement method described in JIS B8224:2005.

The ratio of P-alkalinity/silica concentration in the boiler water was calculated from the measurement values as mentioned above.

[0031]

Test Example 1

Examples 1 to 10 and Comparative Examples 1 to 5

These tests were carried out by operation using the test equipment shown in FIG. 1 which simulates the economizer, whereby the corrosion suppression effects were confirmed.

The original water which had been adjusted to the prescribed quality was charged into the test water tank 2 having the heater 3 installed inside thereof, and then, the temperature was raised to 60°C by operating the heater 3.

By simulating the actual boiler, water was supplied at the rate of 30 L/hour by repeatedly operating the ON/OFF switch of the water supplying pump 6 at every 60 seconds since immediately after the start of the test, while agents were added by the agent supply pump 5 coordinately working with the water supply pump 6. The test solution (supply water), which was the mixture of the original water and the agents, was successively passed through the inlet test column 8, the heat exchanger 16, and the outlet column 10 while controlling the pressure at 0.7 MPa by the back pressure valve 12. The test was conducted for 3 days while repeating 12 hours of operation and 12 hours of suspension.

In each of the inlet column 8 and the outlet column 10, test tubes were installed; and the test was carried out by running the test solution through the test tubes while keeping the temperature at 120°C, with the help of the outlet thermometer 11, by the heat-exchanger 16 which was installed after the inlet test column 8.

The agents, the alkaline ingredient NaOH and the silica ingredient #3 sodium silicate (SiO_2 ; 29% by mass, and Na_2O ; 9.5% by mass) mixed in pure water, was added into the original water supplied from the test water tank 2 in such a way that the test solution (supply water) might have the concentrations as shown in Table 1.

After the prescribed testing time, operation of the equipment was terminated. After cooling, test tubes were taken out from each of the test columns 8 and 10, derusting treatment was done in accordance with JIS K100, and then the corrosion traces caused during the test in the test tubes were counted. These results are shown in Table 1.

Meanwhile, test tubes, having the inner diameter of 9 mm, the outer diameter of 14 mm, and the length of 150 mm, which were made of a carbon steel and defatted, were used.

[0032]

Test solution:

Test solutions prepared by adding the agents to the original water in the way so as to give the concentrations thereof shown in Table 1 were used.

Composition of the original water:

NaHCO_3 : 20 mg/L (as CaCO_3)

Cl^- : 40 mg/L (prepared by NaCl and HCl)

Na_2SO_4 : 40 mg/L (as SO_4^{2-})

[0033]

[Table 1]

	P-Alkalinity in supply water (mg- CaCO ₃ /L)	Silica concentration in supply water (mg- SiO ₂ /L)	Used agents (mg/L)	Inlet test column: Number of corrosion traces	Outlet test column: Number of corrosion traces
Example 1	20	10	None	12	12
Example 2	20	20	None	12	10
Example 3	20	30	None	10	2
Example 4	30	20	None	8	8
Example 5	30	30	None	7	1
Example 6	50	20	None	2	6
Example 7	50	30	None	1	2
Example 8	50	50	None	2	0
Example 9	100	50	None	1	0
Example 10	100	100	None	0	1
Comparative Example 1	15	15	None	32	24
Comparative Example 2	15	40	None	29	14
Comparative Example 3	40	5	None	18	20
Comparative Example 4	15	10	Trisodium citrate (50 as citric acid)	24	50≤
Comparative Example 5	15	10	Trisodium citrate (25 as citric acid) Disodium tartrate (25 as tartaric acid)	26	50≤

[0034]

From the results shown in Table 1, as to the corrosion suppressing effect of the economizer, the corrosion suppressing effects were confirmed in Examples by that in Examples 1 to 10, number of corrosion traces could be suppressed to low in both the inlet and outlet tubes, while it became clear that in Comparative Examples 1 to 5 many corrosion traces were generated in both the inlet and outlet tubes.

[0035]

Test Example 2

Examples 11 to 17 and Comparative Examples 6 to 10

In Test example 1, continuous operation for 3 days was done in accordance with the following Method A and Method B as the water supplying methods. The conditions and results thereof are shown in Table 2.

Method A: water was continuously supplied at 30 L/hour.

Method B: water supply was repeated at 20L/hour and 40 L/hour alternatively for every 60 seconds.

[0036]

[Table 2]

	P-Alkalinity in supply water (mg- CaCO ₃ /L)	Silica concentration in supply water (mg- SiO ₂ /L)	Used agents (mg/L)	Water supplying method	Inlet test column: Number of corrosion traces	Outlet test column: Number of corrosion traces
Example 11	20	10	None	A	15	14
Example 12	30	15	None	A	11	12
Example 13	50	10	None	A	5	7
Example 14	20	30	None	A	12	6
Example 15	50	50	None	A	3	2
Example 16	100	100	None	A	1	0
Example 17	30	15	None	B	10	10
Comparative Example 6	15	15	None	A	40	29
Comparative Example 7	15	40	None	A	33	19
Comparative Example 8	40	5	None	A	22	25
Comparative Example 9	40	5	None	B	20	21
Comparative Example 10	15	10	Trisodium citrate (25 as citric acid) Disodium tartrate (25 as tartaric acid)	A	16	14

[0037]

From the results shown in Table 2, under the condition of continuous supply of water,

the corrosion suppression effect could be confirmed in Examples 11 to 17 and Comparative Example 10. In Example 17, even if the flow rate was changed over time, the corrosion suppression effect could be confirmed.

[0038]

Test Example 3

Examples 18 to 21 and Comparative Example 11

Assuming the operation using the softened supply water, the scaling test was carried out by using the electric test boiler that simulates the tube-type boiler.

Supply water: Nogi Town water (quality of supply water: EC; about 17 mS/m, Cl^- ; 10 mg/L, SO_4^{2-} ; 22 mg/L, M-alkalinity; 22 mg- CaCO_3 /L, and silica; 20 mg- SiO_2 /L)

Temperature of supply water: 25°C (concentration of dissolved oxygen; about 8 mg/L)

Operative pressure; 0.7 MPa

Supply rate of water: 15 L/hour

Blow rate: 1.5 L/hour

Testing time: 72 hours

After the test tubes made of SUS 304 (outer diameter of 30 mm, length of 300 mm, wall thickness of 5mm, and polished with #400 emery paper) into which an electric heater was to be inserted were installed in the test boiler, the electric heater was inserted thereinto, and operation of the test boiler was started.

At the same time with start of the operation, the agents were added to the supply water in such a way that concentrations thereof in the supply water might become those shown in Table 3 by coordinately working with the water supplying pump.

After the test, amount of the scale that was adhered to the test tubes installed inside the test boiler vessel was measured. The scale adhered to the three test tubes installed was scraped off by a cutter knife from the front edge to 200 mm of these test tubes, and then mass of this scraped-off scale was measured. The conditions and results of the test are shown in Table 3.

Meanwhile, the P-alkalinity ingredient NaOH and the silica ingredient #3 sodium silicate (SiO_2 ; 29% by mass, and Na_2O ; 9.5% by mass) were mixed in pure water, and then the mixture was added to the supply water so as to give the concentrations shown in Table 3. In the case that the anti-scaling agent was used, sodium polyacrylate (number average molecular weight of 50,000) was added into the supply water with the amount of 5 mg/L.

[0039]

[Table 3]

	P-Alkalinity in supply water (mg-CaCO ₃ /L)	Silica concentration in supply water (mg-SiO ₂ /L)	Anti-scaling agent	P-Alkalinity in boiler water (mg-CaCO ₃ /L)	Silica concentration in boiler water (mg-SiO ₂ /L)	P-Alkalinity/silica concentration ratio	Amount of adhered scale (g)
Example 18	20	20	None	342	203	1.68	<0.05
Example 19	50	50	None	639	489	1.31	<0.05
Example 20	80	90	None	938	861	1.09	<0.05
Example 21	80	90	Added	943	866	1.06	<0.05
Comparative Example 11	80	120	None	920	1107	0.83	0.38

[0040]

From the results shown in Table 3, it was found that in the softened supply water, in Examples 18 to 21, amounts of the adhered scale were very small, while in Comparative Example 11, in which the silica concentration was high in the boiler vessel with the ratio of P-alkalinity/silica concentration being less than 1.0, the scaling was clearly confirmed.

[0041]

Test Example 4

Examples 22 to 28

Hardness leakage was assumed to be happened in the softened supply water. While adding CaCl₂ as CaCO₃ with the amount thereof being 2 mg-CaCO₃/L into the supply water, the scaling test was carried out under the conditions shown below in the similar manner to the afore-mentioned Test Example 3 by using the electric test boiler that simulates the tube-type boiler.

Conditions and Results are shown in Table 4.

Original water: CaCl₂ was added as CaCO₃ with the amount thereof being 2 mg-CaCO₃/L into the Nogi Town water (quality of original water: EC; about 17 mS/m, Cl⁻; 10 mg/L, SO₄²⁻; 22 mg/L, M-alkalinity; 22 mg-CaCO₃/L, and silica; 20 mg-SiO₂/L).

Addition of agents: P-alkalinity of 50 mg-CaCO₃/L in the supply water, silica concentration of 50 mg-SiO₂/L in the supply water, and anti-scaling agent concentration of 4 mg/L in the supply water).

P-alkalinity/silica ratio in the boiler water: 1.28 to 1.33

Operative pressure; 0.7 MPa

Supply rate of water: 15 L/hour

Blow rate: 1.5 L/hour

Testing time: 72 hours

[0042]

[Table 4]

	Anti-scaling agent	Number-average molecular weight of anti-scaling dispersant	Amount of adhered scale (g)
Example 22	CMC	250000	0.22
Example 23	PAA	4000	0.09
Example 24	PAA	20000	<0.05
Example 25	PAA	50000	<0.05
Example 26	PAA	70000	<0.05
Example 27	PAA	100000	0.14
Example 28	Not added	-	0.69

*CMC: Sodium carboxymethyl cellulose

PAA: Sodium polyacrylate

[0043]

From the results shown in Table 4, under the condition assuming the leakage of hard water, adhesion of the scale was somewhat recognized in Example 28; however, in Examples 22 to 27, adhesion of the scale was hardly recognized.

INDUSTRIAL APPLICABILITY

[0044]

In the water treatment method for a boiler having an economizer of the present invention, by making the P-alkalinity and the silica concentration within the specific ranges, a corrosion suppression effect can be expressed in non-concentrated parts such as a water supplying tube and an economizer, and also scaling in a concentrated part such as a boiler vessel can be prevented.

REFERENCE NUMERALS

[0045]

- 1 Supply water
- 2 Test water tank
- 3, 14 Heater
- 4 Agent supply tank

- 5 Agent supplying pump
- 6 Water supplying pump
- 7 Flow meter
- 8 Inlet test column
- 9 Inlet thermometer
- 10 Outlet test column
- 11 Outlet thermometer
- 12 Back pressure valve
- 13 Heating medium tank
- 15 Heating medium supplying pump
- 16 Heat-exchanger
- 17 Flow regulating valve

CLAIMS

1. A method for treating water of a boiler having an economizer made of a carbon steel in a part or an entire part thereof comprising,
adding an alkaline ingredient and a silica ingredient to a supply water charged into the economizer in such a way that P-alkalinity of the supply water may become in the range of 20 to 100 mg-CaCO₃/L and silica concentration of the same may become in the range of 10 to 100 mg-SiO₂/L.
2. The method for treating water of a boiler having an economizer according to claim 1, wherein the alkaline ingredient and the silica ingredient are added in such a way that ratio of P-alkalinity/silica concentration in boiler water may become 1.0 or more.
3. The method for treating water of a boiler having an economizer according to claim 1 or 2, wherein the alkaline ingredient is an alkaline hydroxide.
4. The method for treating water of a boiler having an economizer according to any of claims 1 to 3, wherein the silica ingredient is a silicate salt.
5. The method for treating water of a boiler having an economizer according to any of claims 1 to 4, wherein an anti-scaling agent is further added to the supply water.
6. The method for treating water of a boiler having an economizer according to claim 5, wherein the anti-scaling agent is an acrylate polymer.
7. The method for treating water of a boiler having an economizer according to claim 6, wherein the acrylate polymer is a polyacrylate salt having number-average molecular weight of 20,000 to 70,000.
8. The method for treating water of a boiler having an economizer according to any of claims 1 to 7, wherein a water supplying pump is comprised a water supplying line, and the water supplying pump is performable an ON/OFF operation in accordance with a water level in the boiler whereby supplying the supply water intermittently.

9 The method for treating water of a boiler having an economizer according to any of claims 1 to 8, wherein the boiler to be used herein is a space-saving once-through boiler.

10 The method for treating water of a boiler having an economizer according to any of claims 1 to 9, wherein the alkaline ingredient and the silica ingredient are added to a water supplying system with which water is supplied to the economizer.