Operating Results of High-AVT (LO) Water Treatment as HRSG Anti-Corrosion (FAC and Phosphate Corrosion) and Hydrazine-free Environmental Measures

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The Kansai Electric Power Co., Inc. introduced High-AVT (LO) water treatment to Himeji No. 2 Power Station which was newly built in 2013, based on the research results at Himeji No. 1 Power Station. This water treatment maintains a pH value higher than the existing method, and hydrazine is not injected into feedwater. It was confirmed through the water quality analysis and equipment inspections that High-AVT(O) water treatment is effective, and this paper presents these results. This achievement is reflected in the 2015 revision of JIS B 8223: Water conditioning for boiler feed water and boiler water.

1. Introduction

Hydrazine has been used in feedwater as an oxygen scavenger at thermal power plants. However, there is concern about its effect on human health, and as a result hydrazine is seeing less use. On the other hand, one of the problems which occurs in feedwater systems is flow accelerated corrosion (FAC). It has been confirmed that increasing the pH value of the feedwater is an effective countermeasure. With such a background, The Kansai Electric Power Co., Inc. introduced High-AVT (LO) water treatment to Himeji No. 2 Power Station in 2013 from the planning stage, based on the research results at Himeji No. 1 Power Station. High-AVT(O) maintains a pH value higher than the existing method, and no oxygen scavengers including hydrazine are used. This achievement is reflected in the 2015 revision of JIS B 8223: Water conditioning for boiler feed water and boiler water (**Table 1**). It was verified through water quality tests and equipment inspections that High-AVT(O) is effective.

Table 1 JIS B 8223 control items and control values of water conditioning for feedwater of heat recovery steam generator for power plants (excerpt)

	Old (2006)	New (2015)		
Treatment method	All-volatile treatment	All-volatile treatment		
Reducing agent	Yes	Yes	No	No
Redox property	Reducing, AVT (R)	Reducing, AVT (R)	Low oxidizing, AVT (LO)	Oxidizing, AVT (O)
pH	8.5 to 9.7	8.5 to 10.3		
Dissolved oxygen, O: μg/l	7 or less	7 or less	Less than 5	5 to 20
Hydrazine, N2H4: μg/l	10 or more	10 or more	—	—

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2. Overview of The Kansai Electric Power Co., Inc. Himeji No. 2 Power Station

Himeji No. 2 Power Station is located in Himeji City, Hyogo Prefecture. It includes conventional power plants and combined cycle power plants consisting of gas turbines, heat recovery steam generators (HRSGs) and steam turbines. The output per combined cycle power plant is 486.5 MW, and there are six units. Unit No. 1 started its operation in August 2013. The major specifications are listed in **Table 2**.

Table 2 Major specifications of No. 1 Unit of Himeji No. 2 Power Station

(1) Plant efficiency	Thermal efficiency approximately 60% (lower calorific value)
(2) Gas turbine	M501J
(3) Steam turbine	One exhaust flow direction reheat mixed pressure condensing type
(4) Heat recovery steam generator	Regenerative reheated triple pressure natural circulation type

Figure 1 indicates the chemical dosing points. Ammonia is injected into the condensate pump outlet, and sodium phosphate is injected into the LP and IP drums. Hydrazine is not used.

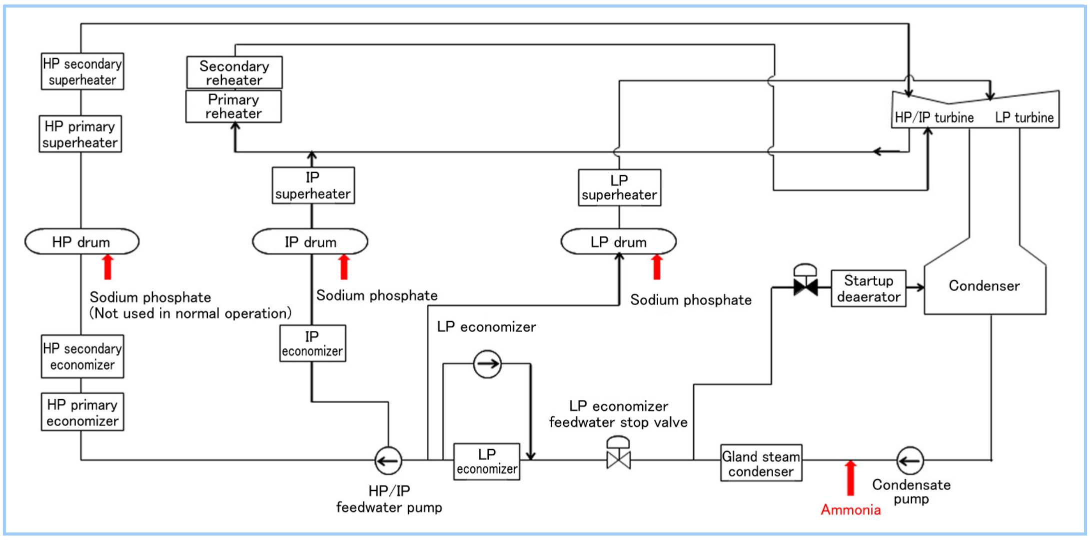

Figure 1 Chemical dosing points of Himeji No. 2 Power Station

3. Revision of JIS B 8223: Water conditioning for boiler feed water and boiler water

3.1 Review of all-volatile treatment (AVT) of boiler feedwater

Generally, as an all-volatile treatment of boiler feedwater, AVT (R) which uses ammonia for pH adjustment and hydrazine as an oxygen scavenger has been used in Japan. The “R” represents “Reducing.” Now the use of hydrazine is not prohibited, but there is concern about its effects on human health, and it is seeing less use. The guidelines issued by the Ministry of Health, Labor and Welfare mention that in order to reduce the exposure to hydrazine, equipment modification (sealing of equipment, etc.), safety and health care education, records of the handling period of hydrazine, and the preservation of records for 30 years should be undertaken. In response to this, AVT(O) and AVT(LO) water treatments that do not use hydrazine were added to JIS in 2015. The “O” represents “Oxidizing” and “LO” represents “Low Oxidizing.” In addition, in the latest revision of JIS, the upper pH limit of feedwater was raised from 9.7 to 10.3 which allows High-AVT(O) or High-AVT(L) water treatment.

3.2 Countermeasure against flow accelerated corrosion (FAC)

One of the problem that occurs in feedwater systems is flow accelerated corrosion (FAC). FAC leads to corrosion wastage in a short time, resulting in the piping exploding. In the latest revision of JIS, the control value of dissolved oxygen and the control value of the pH value were reviewed, so it became possible to apply AVT(O) or High-AVT(LO) as a countermeasure against FAC. A protective oxide layer is formed under AVT (O) by controlling the concentration of dissolved oxygen. High-AVT (LO) suppresses the iron elution by controlling the pH value. **Figure 2** shows the relationship between pH level and thinning rate caused by FAC. It is expected that the thinning rate could be suppressed by raising the pH value from the conventional AVT region (pH 9.0 to 9.6) to the high pH region (pH 9.7 to 10.3).

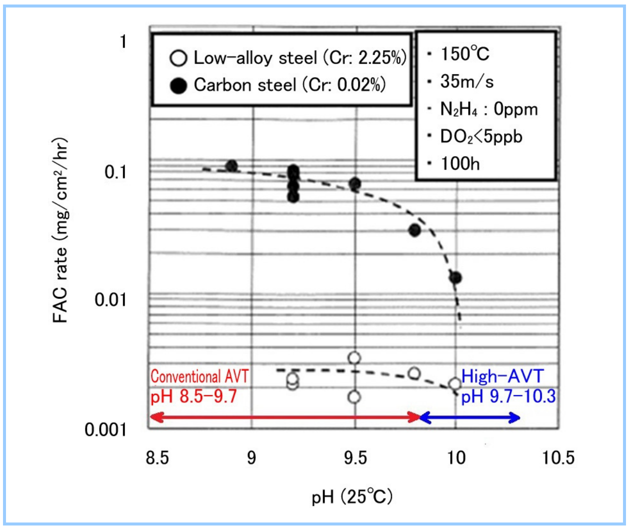

Figure 2　Relationship between pH and thinning rate

4. Notes on applying High-AVT (LO)

As described in the previous section, after the revision of JIS, two water treatment methods; AVT (O) and High-AVT (O) could be applied as a countermeasure against FAC. High-AVT (LO) can be applied by changing the target value of pH, and it will be controlled by electrical conductivity. Notes on applying High-AVT (LO) are described below.

4.1 Exclusion of copper-based materials

Copper-based material needs to be excluded because they would corrode and dissolved as complex ions with ammonia. Copper-based material may also be used for impellers, bearings, valve packings of condensate pumps, union packings and nuts of instruments, etc., in addition to condenser tubes, so care should be taken. In the Himeji No. 2 Power Station project, the materials were checked carefully and copper-based material was excluded and replaced.

4.2 Measure against odor

When the water treatment is changed from AVT to High-AVT, the ammonia concentration will be increased. It becomes about 20 times higher when the pH value is changed from pH 9.0 to pH 9.8. Since the exhaust of condenser vacuum pumps could emit a considerable odor under this ammonia concentration, it is necessary to locate the exhaust discharge point on a roof or at other high locations so that the ammonia odor will not become a problem. In addition, it is necessary to take proper care for ventilation to prevent odor from accumulating in the building. Ammonia could be released from the manual analysis water sampling devices, seal water of pump shafts in the system, etc.

5. Operational results

5.1 pH value

Hydrazine and ammonia are used in the conventional AVT(R) feedwater treatment, but High-AVT (O) only uses ammonia. The ammonia concentration will increase to change the pH value from the conventional pH range (pH 9.0 to 9.6) to the high pH range (pH 9.7 to 10.3). The electrical conductivity, which is an indicator for ammonia dosing control, was calculated. Based on the results, the relationship between the pH value, the ammonia concentration and the electrical conductivity is shown in Figure 3 (solid line). The feedwater pH value was changed from 9.5 to 10.1 in Himeji No. 2 Power Station. According to **Figure 3**, it was verified that the pH and ammonia concentration were well controlled to the target value.

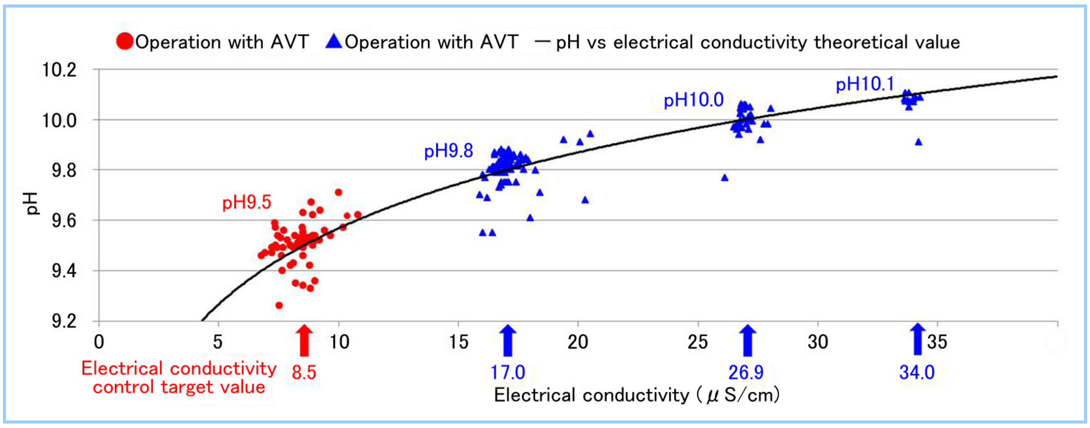

Figure 3 Relationship between electrical conductivity and pH of feedwater

5.2 Dissolved oxygen

Figure 4 shows the change in the dissolved oxygen concentration without dosing hydrazine. It was verified that the dissolved oxygen concentration during the normal operation was maintained around 1 μg/L, where the JIS-specified dissolved oxygen concentration for High-AVT (LO) is smaller than 5μg/L.

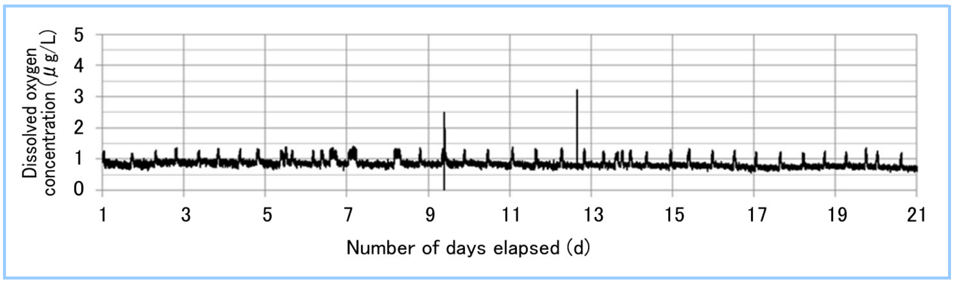

Figure 4 Change over time of dissolved oxygen concentration

5.3 Iron concentration in feedwater

Figure 5 shows the iron concentration in feedwater measured in the aforementioned pH control verification test. The iron concentration in feedwater when operating at pH 9.5, was between 7 to 15 μg/L. The iron concentration in feedwater when operating at pH 9.8 to 10.1, which is within the pH region of High-AVT was 2 to 5 μg/L. It was verified that the iron dissolution could be suppressed by setting the feedwater pH to 9.8 or above.

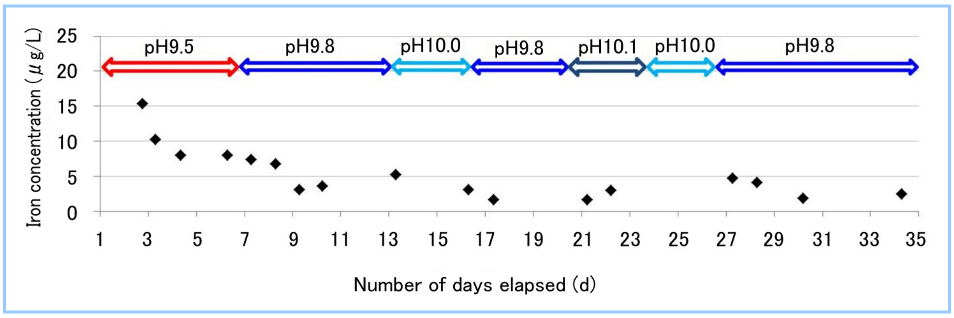

Figure 5 Feedwater iron concentration

6. Internal inspection results

Figure 6 shows the results of internal inspection of HRSG drums conducted one year after the start of operation. No abnormalities such as corrosion were observed, and almost no sludge was accumulated.

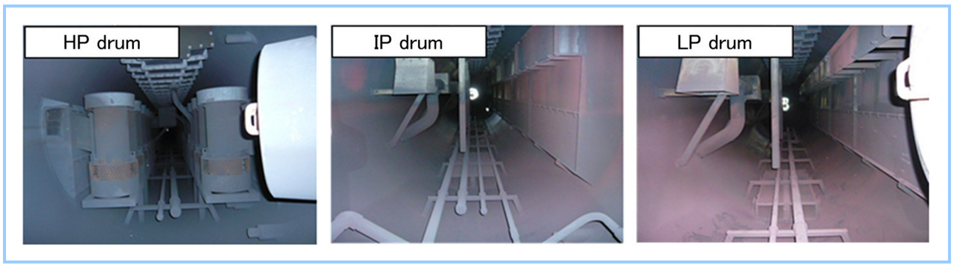

Figure 6 Results of internal inspection of HRSG drums conducted one year after starting operation

7. Conclusion

The water quality analysis of Himeji No. 2 Power Station, which adopted High-AVT (LO) water treatment, was conducted. As a result, the effectiveness of High-AVT (LO) was verified as the following:

(1) Under High-AVT (LO) application, the dissolved oxygen concentration and the pH value of feedwater could be maintained within the standard value range of JIS.

(2) Under High-AVT (LO) application which accompanies a high pH value, the iron concentration in the feedwater was reduced to less than half when compared with the conventional operation with feedwater pH around 9.5.

(3) As a result of drum internal inspection, no corrosion problem was found in the case of High-AVT (LO).

We will continue to study the results of long-term operation with High-AVT (O) and will contribute to the improvement of power plant water treatment and the revision of standards.

References

(1) K. Murata et.al., Proceedings of JSCE Materials and Environments, pp. 77-80 (2006)