A Method for Improvement of Operation Efficiency of Chemical Cleaning Liquid Waste Equipment

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1. Introduction

Maintaining steam generator integrity for stable operation of nuclear power plants is a very important. Nuclear power plants are adhered to the secondary side of the steam generator in the form of sludge as the years of operation increase. The deposits typically consist of a mixture of metal oxides, primarily magnetite(Fe₃O₄), and copper(Cu and CuO). These deposits accumulate on the tube sheet, tube support plates and on the steam generator tube surfaces. The accumulation of corrosion products on heat transfer surfaces and within tubesheet and support regions has been linked with tube corrosion degradation and steam generator secondary side corrosion is an ongoing problem in nuclear power plants with pressurized water reactors. In addition, the accumulation of corrosion products within the support structure has led to severe blocking leading to water level control problems. Blocking and a loss of heat transfer due to tube deposits have led to inability to reach designed power output. As a method for removing such corrosion products, method such as lancing and chemical cleaning are used.

In this study, we have reviewed a method to improve the operation efficiency by improving chemical cleaning liquid waste treatment equipment for the disposal of liquid wastes generated by chemical cleaning.

2. Methodology

Chemical cleaning processes include EPRI SGOG(Electric Power Research Institute Steam Generator Owners Group) process, EdF(Electricité de France) process, and KWU(Kraftwerk Union) process and domestic nuclear power plants use the same process as Table 1.

Table 1. Domestic Chemical cleaning process

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Temperature</th>
<th>Cleaning Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDTA 2%</td>
<td>82 °C</td>
<td>Soft Sludge</td>
</tr>
<tr>
<td>EDTA 20%</td>
<td>110~121 °C</td>
<td>Hard Sludge</td>
</tr>
<tr>
<td>Oxlac Acid 1%</td>
<td>165 °C</td>
<td>Soft Sludge</td>
</tr>
<tr>
<td>EDTA 20%</td>
<td>82~90 °C</td>
<td>Hard Sludge</td>
</tr>
</tbody>
</table>

2.1 Composition of Equipment Operation

The chemical cleaning waste liquid treatment equipment is designed to decompose the liquid waste containing EDTA generated at the secondary side of the steam generator into high temperature. The main component of the equipment is composed of pyrolysis furnace, an oxidation furnace, a catalytic device, a heat exchanger, and HEPA filter and the main function show.

- Pyrolysis Furnace : Pyrolyzing the liquid waste containing EDTA and ammonia (800~1000 °C).
- Oxidation Furnace : Oxidation of air pollutants such as NOx and CO (500~900 °C).
- Catalytic Device : Converts air pollutants such as NOx and CO into dischargeable gases.
- Heat Exchanger : Device to lower the temperature of the exhaust gas as required.
- HEPA Filter : Removal of particulate matter contained in the exhaust gas

The pyrolysis furnace is an electric furnace with a heater at the top and bottom. The electric furnace bottom is composed of two bodies, two inner chambers and four baskets.

Fig. 1. Inner chamber and basket.
2.2 Problem of Equipment

The bottom of the electric furnace receives the chemical cleaning liquid waste from liquid waste tank and performs pyrolysis. The average operating temperature during pyrolysis is 850°C, and the maximum temperature rises up to 1000°C and the operation time is about 10 hours. In this case, the problem that arises when the chemical cleaning liquid waste is treated at a high temperature is the deformation and corrosion of the basket made of carbon steel. These problems are caused by various causes, such as the chemicals in the chemical cleaning liquid waste, the operating temperature. And it decreases the soundness and thermal conductivity of the electric furnace heater and reduces the treatment efficiency of the chemical cleaning liquid waste.

![Image](image1.png)

Fig. 2. Basket deformation and corrosion.

In addition, 353 m³ of chemical cleaning waste were treated in nuclear power plants, and about 69 basket waste were generated by deformation and corrosion.

2.3 Improvement Plan

In order to prevent problems caused by basket corrosion during the treatment of chemical cleaning liquid waste at high temperature, the basket material was studied as stainless steel which is used at high temperature. Stainless steels are formed from oxides on the surface at high temperature only when they are frequently used at high temperature. The rate of growth of oxides depends on many metallurgical and environmental factors and properties of the oxides themselves. Stainless steel strength corrosion damage caused by high temperature gas is oxidation, which is the most common cause of high temperature corrosion, was examined. Oxidation resistance differs depending on the stability of the oxide, bonding properties, adhesion, etc. The reason why stainless steel has a strong resistance to oxidation is usually related to the formation of Cr₂O₃. In addition, chromium and nickel are the most influential factors influencing the composition more than the crystal structure of the alloy. The chromium content in the alloy must be sufficiently high for the Cr₂O₃ scale to remain stable and the chromium concentration must be high, such as 310 stainless steel, in order to have sufficient resistance in an oxidation environment near the maximum operating temperature of 1000°C. And nickel improves mechanical properties Cr₂O₃ scale and prevents diffusion of metal ions to enhance oxidation resistance and is suitable for environments that must withstand high temperatures and heat.

Table 2. Chemical composition of austenite stainless steel

<table>
<thead>
<tr>
<th>ASIS</th>
<th>Cr</th>
<th>Ni</th>
<th>C</th>
<th>Mn</th>
<th>S</th>
<th>P</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>301</td>
<td>17</td>
<td>7</td>
<td>0.15</td>
<td>2</td>
<td>0.03</td>
<td>0.045</td>
<td>1</td>
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<tr>
<td>304</td>
<td>19</td>
<td>9</td>
<td>0.08</td>
<td>2</td>
<td>0.03</td>
<td>0.045</td>
<td>1</td>
</tr>
<tr>
<td>310</td>
<td>25</td>
<td>20.5</td>
<td>0.25</td>
<td>2</td>
<td>0.03</td>
<td>0.045</td>
<td>1</td>
</tr>
</tbody>
</table>

3. Conclusion

Oxidation resistance is also improvement in a high temperature oxidizing environment but high temperature mechanical properties of the material itself are also important variables. Since the strength of austenite stainless steel is generally higher than that of ferrite stainless steel at high temperature, austenite stainless steel was used as a base material. Stainless steel has weaknesses in terms of thermal conductivity and manufacturing cost compared to conventional basket material, but it has strengths in continuity of equipment operation, maintenance and waste reduction. The changes in the basket material will continue to be complemented by comparison with existing material at the planned chemical cleaning liquid waste disposal site.

REFERENCES