Evaluation of the Operational Impacts and Economic Effects for Amine Form Operation of Condensate Polishers in KSNP

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1. Introduction

The main piping materials of the secondary system at NPP is composed of carbon steel, and is occurred flow accelerated corrosion (FAC) and general corrosion during normal operation. Corrosion products generated from the piping and equipment materials of the secondary system are carried into the steam generator through the feedwater and are deposited at the tube crevice. The deposited corrosion products can cause SCC of the steam generator's structural materials. To minimize general corrosion and flow-accelerated corrosion(FAC) of carbon steel, the pH must be maintained at a high level. However, when operating with an increased pH, the injected pH control agent(ETA) is removed through the CPP demineralizer[1,2]. As a result, the demineralizer replacement cycle is shortened, leading to an increase in waste resin, wastewater treatment costs, other operational expenses.

For operational improvement, KHNP CRI was developing amine form operation technology for condensate polishing plant (CPP) to increase pH. It was applied to KHNP OPR NPP for one cycle.

2. Methods

The amine form operation was carried out for approximately 10 months and was performed in two stages. At this time, high-purity resin was used for the MBV(Mixed Bed Vessel) in the first stage operation, and general nuclear grade resin was used in the second stage operation. Additionally, the CBV(Cation Bed Vessel) used general nuclear grade resin. Two CBVs and one MBV were in-serviced during 10 months. One of the CBV was operated with saturated by amines at a flow rate of 500 m^3/hr and another CBV was 50 m^3/hr for water purification. The MBV was operated at a flow rate of 550 m^3/hr. To evaluate the corrosion reduction effect during amine form operation, corrosion product samplers(CPS) were installed at three locations; feedwater system(FW), condensate pump outlet(COP), high-pressure feedwater heater(HP HTR). The iron concentration was analyzed by the following equation once a week.

(1) $A_{CC} = (C_{FW} \times F_{FW} \times T) - [(C_{BD} \times F_{BD} \times T) + (C_{MS} \times F_{MS} \times T)]$

3. Results and Discussion

3.1. Water quality analysis of the secondary system

The behaviors of parameters such as pH, iron concentration, cation conductivity, and impurity concentration(sodium, chloride, sulfate, etc) in secondary system was evaluated through amine form operation.

3.1.1. pH.

The changes in the pH of the secondary system water quality are shown in Fig. 1. The pH of the feedwater increased from 9.8 to 9.87, and the pH of the steam generator increased from 9.92 to 9.98. And the pH of the condensate pump outlet also increased.

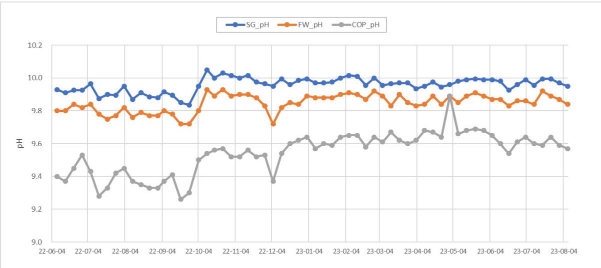

Fig. 1. pH changes of secondary main system

3.1.2. Iron concentration.

The iron concentration was analyzed using CPS, and the results are shown in Fig. 2. As a result, the iron concentration in the feedwater system decreased by approximately 45%. The iron concentrations in other main systems also showed a decrease.

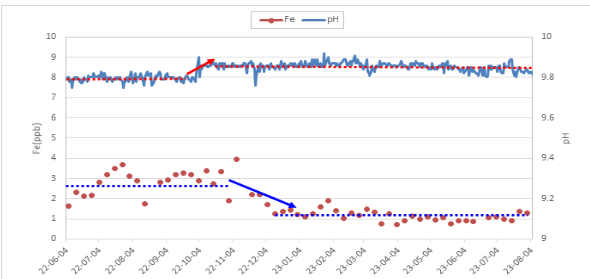

Fig. 2. pH & Iron concentration of Feedwater

3.1.3. Cation conductivity in steam generator.

The cation conductivity of the steam generator increased by approximately 0.63 ㎲/㎝ compared to before the amine form operation. It is determined that the increase in cation conductivity is due to the thermal decomposition of ETA into organic acids, such as acetic acid, formic acid and glycolic acid. To address the issue of continuous increases in cation conductivity, the steam generator blowdown demineralizer was replaced.

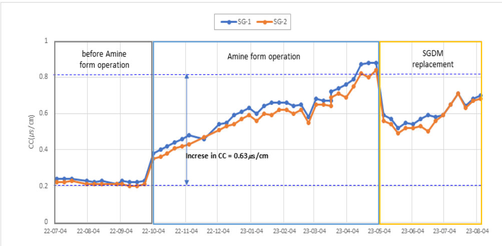

Fig. 3. Cation conductivity of steam generator

3.1.4. Impurity concentration in steam generator.

As a result of reviewing the change in impurity concentration in the steam generator, the impurities were maintained within the control range in the first stage operation. However, during the second stage operation, sodium ion concentration increased and exceeded the control target value. Based on the above results, it was confirmed that it is essential to operate the mixed bed demineralizer using high-purity resin.

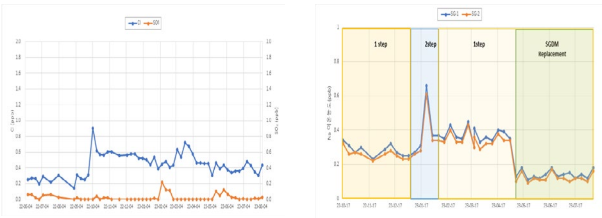
Fig. 4. Impurity concentration of steam generator

3.2. Corrosion reduction effect in secondary system

The iron concentration in the feedwater decreased through amine form operation. Based on this, the iron oxide inflow into the steam generator was calculated using Equation (1). It was found that the amount of iron oxide deposition was decreased by approximately 49% after amine form operation.

Table 1. The amount of sludge accumulation at steam generator

Operation	Iron oxide (kg)		Sludge accumulation
	Inflow rate	Outflow rate	
A(unapplied)	273.54	0.63	272.91
B(applied)	139.86	0.18	139.68
Reduction in accumulated sludge(A-B, kg)			133.23

3.3. Economic effect in amine form operation

The economic effects of amine form operation can be divided into direct and indirect effect. As a direct effect, the costs of ion exchange resin regeneration and wastewater treatment were reduced, resulting in total savings of 120 million KRW. This is because the frequency of ion exchange resin regeneration decreased, leading to a reduction in chemical agents(H_2SO_4, NaOH etc) and wastewater generation. As an indirect effect, the increase in pH led to a reduction in corrosion within the system. As a result, maintenance frequency decreased, leading to an estimated cost savings of 1.06 billion KRW[3].

4. Conclusion

The secondary system pH increased through amine form operation. As the pH increased, the corrosion of components material in secondary system was reduced. As a result, the amount of the corrosion products accumulated in the steam generator decreased. Therefore, it is expected that amine form operation will not only contribute to the integrity of the steam generator but also have a significant effect on cost reduction.

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