

Dispersant Application during SG Wet Layup at SK Unit 1

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1. Introduction

The corrosion products in the feedwater are deposited onto the steam generators (SGs) despite the effort to control them within limit of impurity. This deposit is one of causes for occurrence of SCC (Stress Corrosion Cracking), water level fluctuation and further corrosion of SGs [1]. To minimize corrosion and remove deposit, the nuclear power plants apply high pH to the secondary system and SG chemical cleaning, respectively. But these methods can be costly and carry risks of extended outages or incomplete cleaning.

Another method is an on-line dispersant application. The role of dispersant is to make deposit suspended in the SGs (in Fig.1) [2].

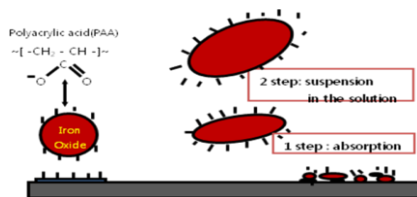


Fig. 1. The reaction mechanism between deposit and dispersant agent

Then, the suspended deposit is discharged to the blowdown system. The iron removal is increased in the blowdown system during the dispersant application. Additional significant benefit in the form of reduced corrosion product transport may be obtained through applying dispersant in the SGs wet lay operational mode. This method helps to reduce the total SGs loading without affecting critical outage activities and with minimal additional effort on the part of the utilities. This study provides the results of the dispersant application trial during the SG wet layup at SK Unit 1.

2. Experimental for PAA (Poly Acrylic Acid) Application

For PAA application, the experimental materials were Alloy 690 and SA 106 Gr.B. Experimental temperature was 40°C. PAA application was tried at SK Unit 1. Before the polymer dispersant trials, the effects of dispersant on the SGs assessed using electrochemical and corrosion testing.

Injection concentration of dispersant was decided during the SG wet layup. PAA was injected to only one (B) of two loops (SK Unit 1 has two loops of A and B) for relative comparative assessment of PAA effects.

3. Results and Discussion

3.1 Electrochemical analysis for Alloy 690 and SA 106 Gr.B according to PAA concentrations

Fig. 2 shows the potentiodynamic curves of Alloy 690 with 1 ppm, 10 ppm and 100 ppm of PAA. As the PAA concentrations increase, the current density (=corrosion rate) and I_{corr} increase also. This is due to increasing organic acid which is decomposed from PAA. The current density at PAA 100 ppm shows a rapid increase.

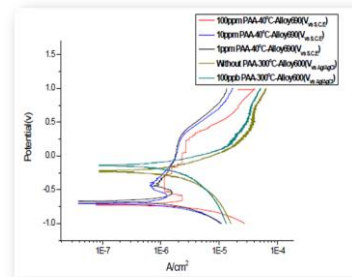


Fig. 2. Potentiodynamic curves for Alloy 690 at 40°C with scan rate of 5 mV/s (Alloy 690 is shown to be relative comparison)

Fig. 3 shows the potentiodynamic curves of SA106 Gr.B with PAA 1 ppm, 10 ppm and 100 ppm. These data show a similar trend as the data of Alloy 690. But the current densities of SA106 Gr.B are much higher than those of Alloy 690. This cause is that corrosion resistance of SA 106 Gr.B has lower than that of Alloy 690.

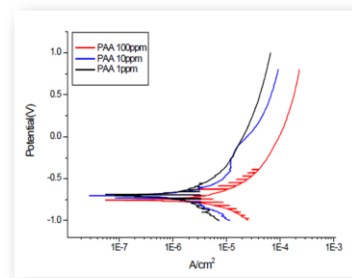


Fig. 3. Potentiodynamic curves for Alloy 690 at 40°C with scan rate of 5 mV/s

3.2 Results of low-temperature corrosion testing

The specimens were cleaned and weighed. Corrosion penetration was then calculated using the following equation:

$$\delta = \frac{1000 \times \Delta m}{2.54^3 \times \rho \times SA} \quad (1)$$

, where δ were the corrosion penetration in mils, Δm was the mass loss in g, ρ was the density of carbon steel in g/cm^3 (7.86 g/cm^3 was used for all carbon or low alloy steel corrosion specimens in laboratory testing), and SA was the exposed surface area in mm^2 .

As the PAA concentrations were increased, the corrosion rates were increased. But the corrosion rates were under corrosion limit (for the SG chemical cleaning process).

Table 1. Corrosion rates of SA 106 Gr.B depending on PAA concentrations at 40°C

No.	PAA con. (ppm)	Mass Loss (g)	Corrosion (mils)
1	1	0.0008	0.0179
2		0.0007	0.0157
3		0.0008	0.0179
4	10	0.0011	0.0249
5		0.0011	0.0245
6		0.0012	0.0268
7	100	0.0016	0.0357
8		0.0017	0.0380
9		0.0017	0.0379

3.3 Use of PAA during SG wet layup

The iron concentration and pH of the layup drain samples with and without dispersant are shown in Table 2. The concentrations of iron in the SG loop B (with PAA) samples were significantly higher than the SG loop A (without PAA). The mass of iron oxide (assumed to be magnetite) removed from loop B was roughly 460 g, whereas 6 g was removed from loop A.

EPRI reported that iron oxide at the TMI-1 was removed about 1.4 kg [1]. The iron removal amount of TMI-1 is about 3 times more than that of the SK Unit 1 (0.46 kg). This is the difference in PAA concentrations injected. The PAA concentration applied at the TMI-1 is about 100 ppm while that of SK Unit 1 is 10 ppm.

Table 2. Fe concentrations during SG wet layup at SK Unit 1

Item date	Fe concentration(ppb)		pH(A/B)
	SG loop A	SG loop B	
'13.04.10	31	159	9.44/9.42
04.12	14	395	9.24/9.27
04.14	24.7	422	9.47/9.40
04.15	25.7	469	9.42/9.35
04.17	11.8	1033	9.45/9.48
04.18	9.9	1514	9.47/9.39

3. Conclusions

As the PAA concentrations were increased, the corrosion rates of Alloy 690 and SA 106 Gr.B were increased. The corrosion rate of Alloy 690 was 2 times less than that of SA 106 Gr.B at 100 ppm of PAA based on the electrochemical experimental.

There were no significant feasibility problems with application of PAA during the SG wet layup. The reasonable estimation of the additional mass removed by the presence of PAA during SGs wet layup is 460 g. The iron removal depended on PAA concentration injected based on the comparative results of the SK Unit 1 and TMI-1. It is expected that injection of PAA into the SG result in a significant decrease in the amount of iron transported to the SGs during the startup.

REFERENCES

- [1] Steam Generator Management Program: Generic Plant Qualification and Application Plan for Dispersant Use during Steam Generator Wet Layup. EPRI, Palo Alto, CA: 2011.1022826.
- [2] Dispersant for Tube Fouling Control, Volume I: Qualification for a short-Term Trial at ANO-2, EPRI, Palo Alto, CA, and Entergy Operations, Russellville, AR: 2001.1001422.