The Evaluation of Crevice Corrosion of Inconel-600 and 304 Stainless Steel in Reductive Decontamination Solutions

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1. Introduction

Chemical decontamination of the primary coolant system in PWR reactor often causes the corrosion to the base metal. It gives rise to the structural weakness of the system and increases the risk of the critical accidents. Therefore it is required to evaluate the corrosion when applied and further the improvement of decontamination solution in necessary. In this sturdy, we investigated the characteristics of corrosion to Inconel-600 and type 304 stainless steel which are mainly used for the steam generator and primary system of PWR reactor respectively. We conducted the corrosion test for the HYBRID (HYdrazine Based metal Ion Reductive decontamination) which was developed in KAERI, Citrox and Oxalic acid solutions used in reductive decontamination of the inner surface of PWR. Since Citrox and oxalic acid solution were well-known conventional decontamination solutions [1], it is meaningful to compare the corrosion result of HYBRID with those solutions to confirm the corrosion compatibility. In order to obtain visible results in a limited time, we conducted the crevice corrosion tests under harsh condition.

2. Experimental Methods

Inconel-600 and 304 stainless steel specimens were prepared with the dimension of 20×20×2mm after polishing with silicon carbide polishing paper of #1200 grit. To make harsh environments, the heat treatment of specimens was conducted at 600°C for 20 hours before polishing of specimens. Crevice specimens were made as shown in Fig. 1.

Fig. 1. Crevice specimen.

The compositions of both reductive decontamination solutions used for crevice corrosion test are shown in Table I. Specimens were corroded in decontamination solutions for 20 hours at 95°C. To control the oxygen dissolution, we purged nitrogen gas in the decontamination solution for 30 minute before loading the specimens in the decontamination solution. Crevice corrosion induced to crevice specimens was compared to normal corrosion for normal specimens at the same experimental conditions.

Table I. Problem Description.

Decontamination solution	Chemical composition
HYBRID	0.07M N_2H_4 + 0.5mM Cu^+ + HNO_3(pH=3.0)
Citrox	5.5mM oxalic acid + 7.14mM Citric acid + NaOH(pH=3.0)
oxalic acid solution	15.84mM oxalic acid

3. Results

After the corrosion test for 20 hour in reductive decontamination solution, the surface of the both type of specimens was looked over through the optical microscope and weight loss of specimens was measured. The qualitative results of localized corrosion of specimens are shown in Fig. 2. In this figure, 304 stainless steel and Inconel-600 in HYBRID have no corrosion, while both type crevice specimens in Citrox and oxalic acid solutions have the localized corrosion with pitting on the surface. In addition, IGA (Intergranular attack) was observed on the Inconel-600 specimen in Citrox and oxalic acid solution. Especially, more severe IGA on both specimens was found in oxalic acid solution. The compared results of weight loss of crevice specimens and normal specimens are shown in Fig. 3. The weight loss was hardly appeared in both type specimens in HYBRID solution. But, relatively large amount of the weight loss was observed in Citrox and oxalic acid solutions. Specially, 304 stainless steel in oxalic acid solution had conspicuously increased weight loss by crevice corrosion.

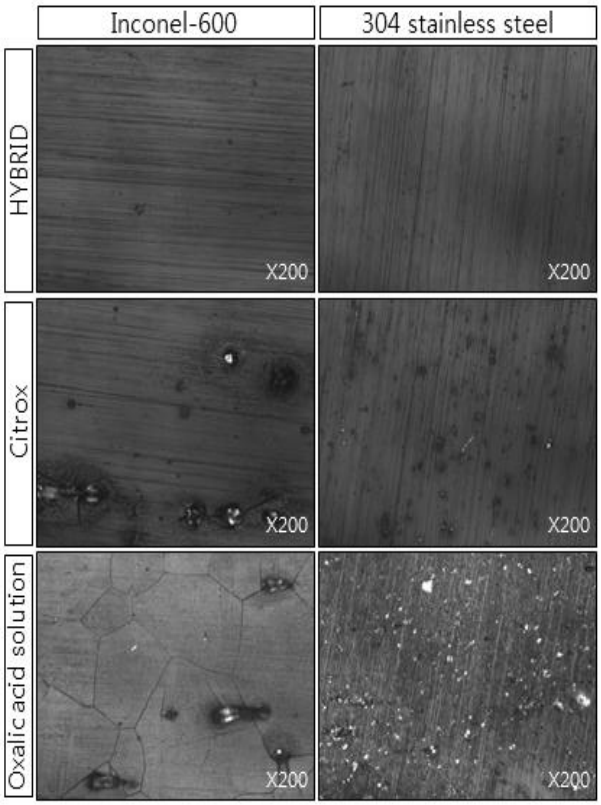

Fig. 2. Surface appearance of crevice and normal corrosion specimen observed by optical microscope.

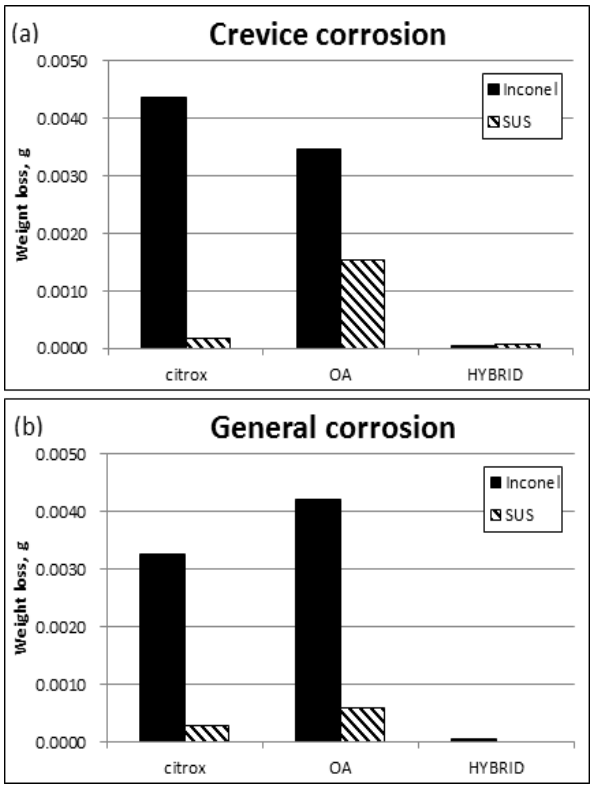

Fig. 3. The comparative results of the weight loss of each specimen in Citrox, oxalic acid solution and HYBRID decontamination by the crevice corrosion (a) and general corrosion (b).

4. Conclusion

According to the results of crevice corrosion tests, we can conclude that metals such as type 304 stainless steel and Inconel-600 in HYBRID are very stable against crevice corrosion. On the other hand, those metals in Citrox and oxalic acid solutions were very susceptible to the crevice corrosion. Especially when using the oxalic acid solution, severe corrosion was observed not only Inconel-600 but also 304 stainless steel. The degree of corrosion can be expressed as; HYBRID << Citrox < OA. Conclusively, our results support that the HYBRID is more stable to the corrosion of structural materials in primary system than other Citrox and oxalic acid solutions. This finding will appoint the HYBRID solution as a candidate to solve the corrosion problem which is often issued by existing chemical decontamination processes.

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REFERENCES

[1] "Dismantling Techniques, Decontamination Techniques, Dissemination of Best Practice, Experience and Know-how", AF-Colenco Ltd, (2009)