The Study for Method of Full System Decontamination to Remove the Inner CRUD Layer on the Primary Piping

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1. Introduction

In preparation for dismantling Kori Unit 1 nuclear power plant, various parts should be considered on worker's exposure and waste reduction. In order to satisfy this requirement, a full system decontamination, mainly chemical decontamination, is used before the actual decommissioning activities. Generally, widely known full system decontamination methods over the world are CORD-UV, NITROX-E, and ASDOC D-MOD.

In this experiment, chemical decontamination method (Oxidation and Reduction process) is applied to find a way to decontaminate the inner surface of pipe system. From the test, we evaluate decontamination performance of this method.

The specimens are selected to chromium-nickel alloy stainless steels used for RCS pipe material and component material. The expected properties of the crud are selected as metal oxides such as iron and chromium based on Reference [1].

2. Experiment

2.1 Experimental equipment and reagents

The experimental equipment consisted of a closed system using a circulation pump to circulate the aqueous solution in the reaction tank, and the temperature of the aqueous solution is maintained at 80℃ by a heating controller.

Two reagents are used for the experiment : potassium permanganate($KMnO_4$) for oxidizing decontamination process, and oxalic acid($C_2H_2O_4$) for reducing decontamination process

2.2 Experimental method

2.2.1 Preparation. Put the specimen and potassium permanganate aqueous solution (4 L, 300 ppm) in the reaction tank and keep the temperature of the aqueous solution at 80℃ by using the heating controller.

2.2.2 Oxidizing Process. $HMnO_4$ acts as an oxidant, and oxidizes and removed the insoluble Cr_2O_3 layer to soluble CrO_4^{2-}.

$$Cr_2O_3 + 2HMnO_4 + H_2O \rightarrow 2HCrO_4^{2-} + 2MnO_2 + 2H^+ \quad (1)$$

2.2.3 Preparation for reducing process. After the oxidizing process, the excess amount of $C_2H_2O_4$ is added and the reaction is repeated for 3 hours. At this time, the same amount of $C_2H_2O_4$ is further injected once per hour.

$C_2H_2O_4$ is required to maintain a certain concentration because it plays a role of reducing MnO_2 to Mn^{2+} and reducing iron in the next step

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$$2H^+ + MnO_2 + C_2H_2O_4 \rightarrow Mn^{2+} + 2H_2O + 2CO_2 \quad (2)$$

2.2.4 Reducing process. Fe_3O_4 is reduced and

removed as soluble Fe^{+}.

$$Fe_3O_4 + 4H_2C_2O_4 \rightarrow 3FeC_2O_4 + 2CO_2 + 4H_2O \quad (3)$$

The Fig. 1 shows the changes in the oxidizing process and the reducing process when the reagents are added.

Fig. 1. Oxidizing process (Left), Reducing process (Right).

2.3 Results and discussion

After the test, the surface of the specimen is observed with a scanning electron microscope. Fig. 2 is the scanning electron microscope (SEM) image that the uncoated base material (Blank) and before/after decontaminated specimen. Before decontamination, the surface is plated with chromium and a smooth surface is observed. After the decontamination, the plated chrome is peeled off and the surface on which the base material was exposed is observed.

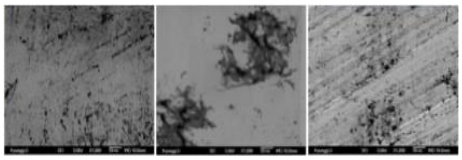

Fig. 2. Scanning Electron Microscope image.
[Blank (Left), Before Decontamination (Mid), After Decontamination (Right)]

Fig. 3 is a photograph of the specimen after chemical decontamination. As shown in the Fig. 3, the base material is visible in the area where the chemical reaction occurs, but in the other side, the chromium plating remains. It is considered that a sufficient reaction time and more decontaminating agent are required to achieve higher decontamination efficiency

Fig. 3. Specimen before (Left) decontamination and after (Right) decontamination.

3. Conclusion

As shown in the above test results, we know that chemical decontamination method(oxidation and reduction process) can applied to decontaminate the contaminated area such as the crud layer of the surface, and it is confirmed that the direct contact of the worker is minimized.

REFERENCES

[1] IAEA, Lawrence, E. Boing, 10. 2006, “Decommissioning of nuclear facilities – Decontamination technologies”.

[2] Final report on Application of Decontamination & Dismantling Technology for Old Steam Generator.