Cerium Effect on Decontamination of Stainless Steel 304 Metal Oxide

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1. Introduction

The primary system of the Pressurized Water Reactors (PWR) are operating in a closed cycle at a pressure of about 15 MPa and a temperature of 270~310°C. The main components of the system are consisted of zirconium alloy as fuel cladding material and inconel alloy and other major components are made of stainless steel with excellent corrosion resistance. As the operation of a nuclear power plants were increased, radioactive corrosion products (CRUD) generated by system corrosion attach to the surface of the primary system. It has known the two types of oxides that was impregnated on the system surface another oxides grown inside the metal. It is reported that the ratio of the radioactivity from these two oxides is almost the same.[1,2]

Radioactive corrosion products (CRUD) generated from the reactor coolant system are known to be composed of the magnetite and nickel ferrite ($NiFe_2O_4$) including various chromium oxides($FeCr_2O_4$, Fe_2CrO_4, $NiCr_2O_4$). The composition of these oxide films are similar to that of nickel ferrite and is expressed as a non-stoichiometric mixed oxide of spinel structure $(Fe)_{3-xy}(Ni)_x(Cr)_yO_4$.[3,4] The major chemical decontamination method that has been developed so far is the reduction and dissolution of Fe oxide film by a reducing agent. The chromium oxide in the corrosion oxide is oxidized to Cr (III) → Cr (IV) and the iron oxides dissolve when reduced to Fe (III) → Fe (II).

In this study, the cerium effect on chemical decontamination characteristics of the metal oxide film formed on the surface of the SUS 304 material was investigated to determine the optimal conditions as function of cerium concentration and operating temperature.

2. Evaluation of Decontamination Performance

The experimental apparatus shown in Fig. 1 was fabricated to test the various reaction conditions for the dissolution of SUS 304 corrosion oxide film for the sulfuric acid-cerium decontamination. The apparatus used in this research is composed of a decontamination tank, a decontamination make-up tank, and a regeneration tank. The cylindrical type decontamination tank and the regeneration tank were made of SUS 304 and the inner surfaces were coated with Teflon to prevent corrosion. The SUS 304 corroded specimen used in the test was cut to a size of 15 mm in radius and 1.5 mm in height. The metal oxide of the test specimen were corroded for 72 hours at 45~53 kg/cm^2 under EDTA-hydrazine mixed solution by using autoclave.

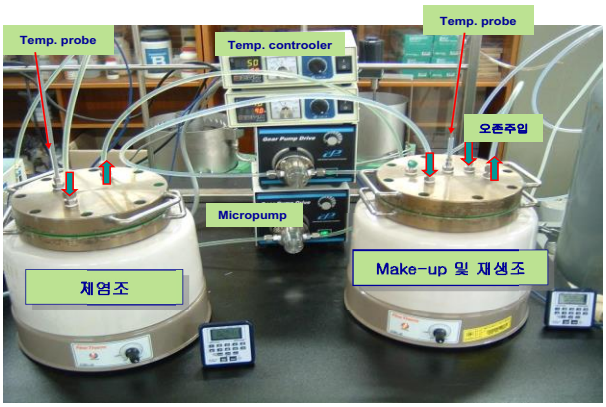

Fig. 1. Decontamination Test Apparatus.

In order to evaluate the effect of Ce(IV)

concentration on the decontamination of SUS 304 corroded oxidation specimens, the weight change of test specimen were measured at the various cerium concentration of 2, 3.5, 5 and 10 *m*M. As a result, the corrosion oxide film of SUS 304 was not completely removed even after the decontamination time of 6 hours at the Ce (IV) concentration of 2 and 3.5 mM, while it took 6 hours at 5 mM and 4 hours at 10 mM to remove all oxide film (Fig. 2).

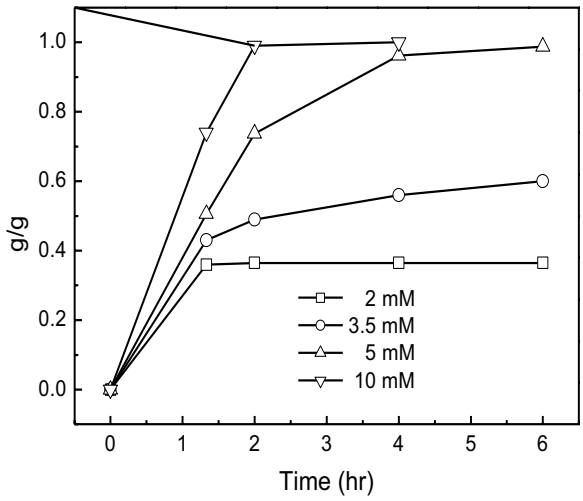

Fig. 2. Effect on the Ce(IV) on oxide removal.

The evaluate the effect of reaction temperature on decontamination were investigated at four different reaction temperatures of 60, 70, 80 and 90^{o}C at 10 mM Ce(IV) concentration. As shown in Fig. 3, the removal rate of was tested to increase at high reaction temperature. In the case of SUS 304, the oxide film were removed within 2 hours. From these results, it is confirmed that the best decontamination efficiency was tested under the Ce (IV) concentration of 10 mM at 60°C.

3. Conclusion

The experimental tests were investigated the decontamination characteristics of the contaminated SUS 304 corrosion oxide in the primary system operating environment. solution. It was evaluated that sufficient decontamination performance was secured under conditions of Ce (IV) concentration of 10 mM and reaction temperature of 60°C for SUS 304 corrosion oxide film removal.

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