

# Development of Experimental Method to Simulate the Corrosion Products in the Primary System of Nuclear Power Plant

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## 1. Introduction

Corrosion products are recognized as one of the major sources of occupational radiation exposure for nuclear power plant workers [1]. Numerous studies have been conducted on the primary water chemistry to reduce the amount of crud in the primary circuit to avoid the radioactivity build-up in the plant. However, experiments with crud are restricted in laboratory because the crud is highly radioactive material. The objective of this study is to develop the simulating method of corrosion product in nuclear power plant.

## 2. Tests and Results

### 2.1 Simulation of corrosion products in high temperature water

High temperature – high pressure apparatus was developed to simulate nickel ferrite corrosion products which were main compositions of the radioactive crud in the nuclear power plant. Corrosion product similar to the crud was obtained by a tube accumulator system. Nickel alloy and carbon steel were corroded at 270 °C in the corrosion product generator. Ni ions and Fe ions dissolved by corrosion reaction were able to be transported to the accumulator through a stainless steel pipe because the crud generation mechanism was the solubility change with temperature. Figure 1 shows the schematic diagram of tube accumulator system. Stainless steel tube was installed replacing autoclave accumulator for a repetitive test.

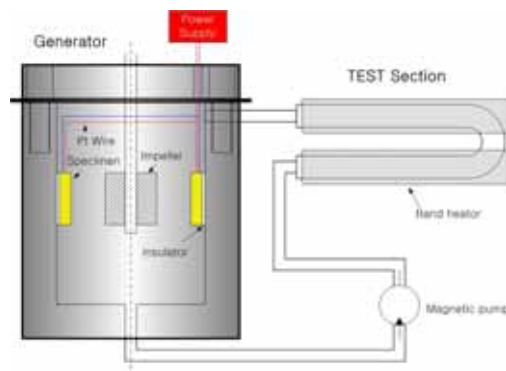


Figure 1. Schematic diagram of high temperature – high pressure crud generator.

To evaluate the properties of simulated corrosion products, scanning electron microscopy and EDAX analysis were performed. The electron microscopy of corrosion product showed the needlelike or crystal structure of oxide depending on precipitating location. The Fe: Ni: Cr atomic ratio of crystal oxide shown in figure 2 was 61.29: 10.88: 17.55. Average bulk formula of crystal oxide was  $\text{Ni}_{0.53}\text{Fe}_{2.47}\text{O}_4$ , and it was similar to the crud on nuclear fuel cladding [2].

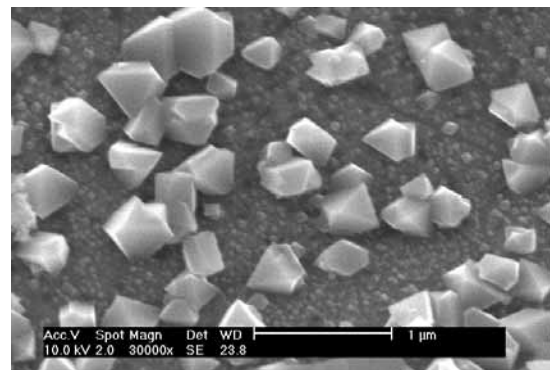


Figure 2. SEM image of corrosion products that have been generated at pH<sub>300</sub> 6.9 solution using the crud generator.

### 2.2 Preparation of nickel ferrite powders using mixed Ni and Fe tartrate

The mixed metal oxide powder was obtained by thermal decomposition of a mixed tartrate which was prepared using the tartaric acid solution containing ferrous nitrate and nickel nitrate [3]. Average bulk formula of metal oxide was varied with concentration of nitrate and test results are shown in table 1.

Fe nitrate: Ni nitrate	Fe (At%)	Ni (At%)	Ni/Fe ratio	Bulk formula
2:1	8.16	0.56	0.07	$\text{Ni}_{0.21}\text{Fe}_{2.79}\text{O}_4$
1:1	6.10	1.84	0.3	$\text{Ni}_{0.9}\text{Fe}_{2.1}\text{O}_4$
3:1	7.43	0.48	0.06	$\text{Ni}_{0.19}\text{Fe}_{2.81}\text{O}_4$

Table 1. Metal contents and average bulk formula of metal oxide particles with variation of nitrate ratio.

80% of metal oxide particles were smaller than 25 μm as shown in figure 3, and crystal size of oxide was about 100 nm. The mixed metal oxide powder had

0.008 A-m<sup>2</sup>/g saturation magnetization and 17.3 kA/m coercive force and showed ferrimagnetic behavior [4].

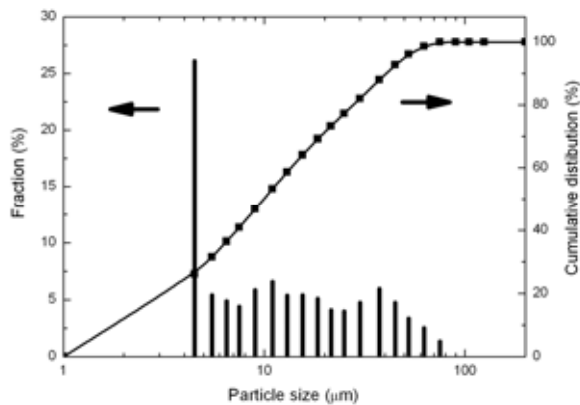


Figure 3. Size distribution of metal oxide particles in fluid.

### 3. Conclusions

High temperature – high pressure apparatus was developed to simulate nickel ferrite corrosion product. Average bulk formula of corrosion product was Ni<sub>0.53</sub>Fe<sub>2.47</sub>O<sub>4</sub> and it was similar to the crud on nuclear fuel cladding

The mixed Ni – Fe oxide powder was obtained by thermal decomposition of a mixed tartrate. Crystal size and particle size of mixed oxide were less than 100 nm and 100 μm, respectively. The oxide showed a hard magnetic behavior.

### REFERENCES

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