An Experimental Study on the Melting Decontamination for Radioactive Metal Waste Treatment Using Nuclide Coated Specimens

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1. Introduction

Melting decontamination process is applied widely for radioactive metal waste treatment because melting process make the pollutants of metal waste uniformly and make easier to measure the residual radioactivity[1].

In this paper, to develop optimal melting decontamination process of radioactive metal waste evaluated the removal rate of Co-60, Cr-51, Cs-137 nuclides according to melting parameters through the melting experiment using induction furnace. For this experiment, we investigated the main radioactive nuclides using thermal insulator which covered RCS (Reactor Coolant System) Loop of KORI unit1 and made the specimens coated with investigated nuclides.

2. Methods and Results

2.1 Nuclides Investigation of RCS Loop

In order to investigate the main radioactive nuclides of the RCS Loop of KORI unit1, we took measurement samples at inside and outside of the thermal insulator of the RCS equipments and pipes(fig.1). In the results of analysis, Co-60, Cr-51 and Xe-133 were detected on the inside of the thermal insulator and Co-60 and Cs-137 were detected on the outside of the thermal insulator at all sampling locations. The nuclides and their radioactivity found in measurement samples are summarized in table 1.

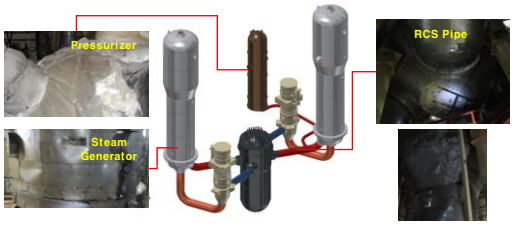

Fig. 1. Sampling locations of RCS Loop.

Table 1. Nuclide Distribution of Insulation of RCS Loop

Sampling Location		Nuclide	Activity(Bq/g)
Steam Generator	Inside Insulation	CR-51	1.22E+01
		CO-60	8.89E+00
		XE-133	5.71E+00
RCS Pipes	Inside Insulation	CO-60	3.14E+00
		SB-124	1.42E+00
		XE-133	1.01E+00
		CS-137	3.98E+00
	Outside Insulation	CR-51	7.58E+00
		CO-60	4.14E+00
		XE-133	2.97E-01
Pressurizer	Inside Insulation	CO-60	1.37E+00
		XE-133	5.36E-01
	Outside Insulation	CO-60	4.99E-01
		CS-137	3.35E-01

2.2 Melting Decontamination Experiment

We experimented melting decontamination effect of Co-58/60, Cr-51 and Cs-137 nuclides using induction furnace while varying the melting parameters(slag weight, composition, basicity). We prepared metal specimens coated with each nuclide as shown in table 2.

Table 2. Nuclides Coated Specimen

Nuclide Coating	Co3O4	Cr2O3	CsCl
Coating times	3 times	3 times	3 times
Solidification temp	200℃	200℃	Room Temp'
Solidification time	30 min	30 min	180 min
Resin ratio	50w%	50w%	50w%
Specimen image			

We melted the nuclide coated specimens and slag in a graphite crucible (purity: 99% more) using the induction furnace. Information of slag added to remove nuclides from specimens is as shown in table 3. Weight changes before and after melting are as shown in table 4.

Table 3. Test parameters for induction melting test.

Sp. No	Coated Nuclide		Slag		B ratio
	kind	Weight	Composition (W%)	Weight	
1	Co-58/60	1.39 g	SiO2(50)-CaO(30)-Al2O3(20)	72 g	0.6
2	Co-58/60	1.10 g	SiO2(50)-CaO(30)-Al2O3(20)	36 g	0.6
3	Co-58/60	1.43 g	SiO2(50)-CaO(30)-Al2O3(10)-Fe2O3(10)	36 g	0.6
4	Cr-51	2.33 g	SiO2(50)-CaO(30)-Al2O3(20)	72 g	0.6
5	Cr-51	2.09 g	SiO2(50)-CaO(30)-Al2O3(20)	36 g	0.6
6	Cr-51	2.09 g	SiO2(50)-CaO(30)-Al2O3(10)-Fe2O3(10)	36 g	0.6
7	Cs-137	4.88 g	SiO2(50)-CaO(30)-Al2O3(20)	72 g	0.6
8	Cs-137	3.72 g	SiO2(50)-CaO(30)-Al2O3(20)	36 g	0.6

Table 4. Weight information before/ after melting

Sp. No	Before melting(g)			After melting(g)		
	Specimen	Slag	Coated Nuclide	Specimen	Slag	Nuclide in slag
1	356.7	72	1.39 g	352.9	85.2	0.192
2	355.1	36	1.10 g	352.1	53.9	0.118
3	356.4	36	1.43 g	352.5	50.4	0.035
4	364.8	72	2.33 g	358.0	92.1	1.65
5	362.3	36	2.09 g	356.2	55.3	1.91
6	362.9	36	2.09 g	356.8	48.2	1.93
7	364.8	72	4.88 g	358.0	83.22	0.47
8	362.3	36	3.72 g	356.2	61.82	0.36

We separated the molten metal and slag after melting, and then analyzed the weight percent of Co, Cr, Cs nuclides in the slag by XRF. The removal rates of nuclides are calculated using the equation (1) and the results are as shown in table 5.

$$D(\%)=w\%\times m(g)/M(g) \quad (1)$$

(D(%):Removal rate, w%:Nuclide weight percent in the slag, m(g):Weight of slag after melting, M(g):Weight of nuclide coated on the specimen)

Table 5. Nuclide removal rate by Slag after melting

Sp.No	Coated Nuclide	Weight(g) (in Specimen)	Weight(g) (in Slag)	Removal rate(w%)
1	Co-58/60	1.39	0.192	13.8
2	Co-58/60	1.10	0.118	10.9
3	Co-58/60	1.43	0.035	2.24
4	Cr-51	2.33	1.65	70.8
5	Cr-51	2.09	1.91	91.3
6	Cr-51	2.09	1.93	92.3
7	Cs-137	4.88	0.47	9.9
8	Cs-137	3.72	0.36	10.0

3. Conclusion

We carried out decontamination experiments of the metal waste coated the field nuclides which investigated in the RCS Loop of KORI Unit1 using induction furnace. In the experiment, we got 2.2 ~ 13.8% removal rate of Co, 70.8 ~ 92.3% removal rate of Cr and 10.0% removal rate of Cs according to the change of slag composition and weight. But we need more experiment for increasing removal rate of Co and Cs.

REFERENCES

[1] Park Jin Ho, et al., "Development of post-decontamination process after integrated EPN treatment", Korea Atomic Energy Research Institute, (2010).