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Study on the Experiment of Melting Decontamination for Thermal Insulation Waste of Reactor Coolant System

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1. Introduction

The purpose of this study is to develop effective method for volume reduction and decontamination of glass wool thermal insulator and their steel cover which are difficult to reduce the volume because of low specific gravity and large volume of glass wool among the low and intermediate radioactive waste. For this study we investigated the main radioactive nuclides of thermal insulator which covered RCS (Reactor Coolant System) Loop of KORI unit1 and also estimated the amount of thermal insulation waste to be generated during the dismantling work through the measurement of the insulation thickness. In addition, we evaluated decontamination performance of Co and Cr nuclides, which are main nuclide species investigated in the field, through the melting test of nuclide coating specimens using induction furnace.

2. Methods and Results

2.1 Nuclide Analysis of thermal insulation material

In order to analyze the nuclides in thermal insulator of the RCS Loop of KORI unit1, we took actual measurement samples at inside and outside of the thermal insulator of the each equipments and pipes. In the results of analysis, Co-60 and Xe-133 were detected on the inner side of the thermal insulator and Co-60 and Cs-137 were detected on the outer side of the thermal insulator at all sampling locations. The nuclides and their radioactivity found in measurement samples are summarized as shown in table I.

Table I: Nuclide Distribution Analysis of Insulation of RCS

Sampling Location	Nuclide	Activity(Bq/g)
SG (Steam Generator)	CR-51	1.22E+01
	CO-60	8.89E+00
	XE-133	5.71E+00
RCS Pipe	SB-124	1.42E+00
	XE-133	1.01E+00
	CS-137	3.98E+00
	CR-51	7.58E+00
	CO-60	4.14E+00
PZR (Pressurizer)	CO-60	1.37E+00
	XE-133	5.36E-01
	CS-137	3.35E-01

2.2 KORI Unit 1 RCS Insulation Volume Calculation

In order to estimate the amount of the thermal insulation waste of the RSC Loop of KORI unit1, we measured the thickness of the thermal insulator in the field, excluding the reactor. And we calculated the volume of thermal insulator through adding the measured thickness on the 3D modeling of RCS Loop in Fig.1. As a simulation result, the total amount of thermal insulator was estimated to be about 111 cubic meters. If there is no effort to reduce the volume, about 662 drums (200ℓ/drum, filling rate of 85%) will be needed and total cost for waste treatment will be KRW 13.2 billion (KRW 20 million per drum). If we can reduce the volume of the thermal insulator such as glass wool to 1/20 times reduction through incinerating, then the volume will be about 34drums and costs can be reduced to KRW 680 million.

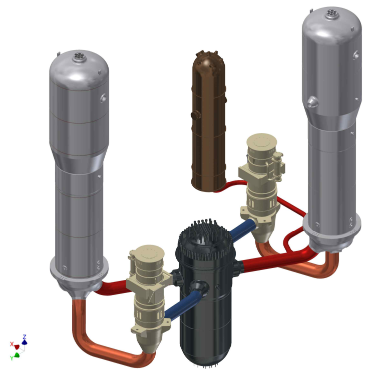

Fig. 1. Kori Unit1 RCS Loop 3D Modeling.

Table II: Thermal Insulation Volume of RCS

Equipment	Thickness (mm)	Volume (㎥)	Drum (ea)
Reactor	140	17.35	102
SG(Steam Generator)	130	66.74	393
Hot Leg	150	5.44	32
Cold Leg	150	3.95	23
RCP Bottom	130	3.12	19
SG-RCP Pipe	150	10.23	60
PZR(Pressurizer)	50	4.09	24
Hot Leg-PZR Pipe	50	1.47	9
Total		112.39	662

2.3 Specimen Preparation

For treatment of thermal insulation waste, first we analyzed the possibility of melting decontamination of steel plate which wrapped the glass wool thermal insulator. We prepared non-radioactive carbon steel specimen coated with Co and Cr nuclides among the radioactive nuclides found in the field. In order to simulate the actual radioactive contamination specimen, carbon steel base material (Outer Diameter: 2cm, Height: 3cm)was corroded with hydrochloric acid under normal temperature conditions to form a corrosion layer 800 ㎛ thickness on the surface of the base material during 12 hours. Fig .2 shows the images of corrosion thickness according to corrosion time.

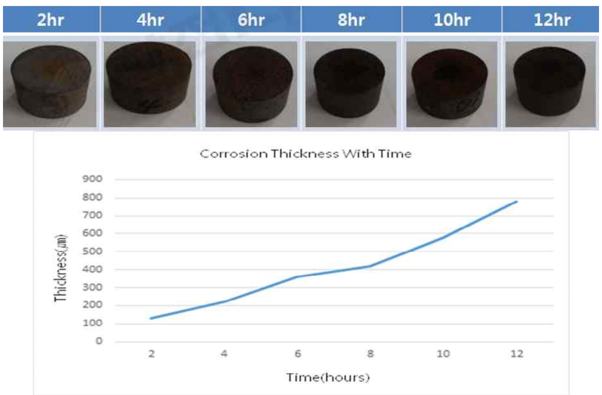

Fig. 2. Corrosion thickness with time.

We coated Co and Cr nuclides on the corroded metal surface for making simulated nuclide specimen as shown in Fig. 3. For coating, we sprayed reagent mixed with resin containing Co and Cr nuclides on the corroded metal surface and then heated at a 200℃ for more than 30 minutes.

	Co3O4 coating	Cr2O3 coating
Number of Coating	3 times	3 times
Solidification temp(℃)	200	200
Solidification time)	More than 30 min	More than 30 min
Resin ratio(w%)	50	50
Specimen		

Fig. 3. Specimens coating method and image.

2.4 Melting Decontamination Test and Analysis

We tested decontamination effect of specimens coated with Co and Cr nuclides by induction melting while varying the test parameters (slag weight, composition, basicity, and melting time) as shown in Table 3.

The nuclide coating specimens and slag were placed in a graphite crucible (purity: 99% or more) and melted using an induction furnace. The weight change before and after melting, the weight of coated nuclides are shown in the Table IV and V.

Table III: Parameters for melting of simulated specimens

No	Slag Composition(w%)	Slag weight	B ratio	Meltin g time
1	SiO2(50)-CaO(30)-Al2O3(20)	72g	0.6	1800s
2	SiO2(50)-CaO(30)-Al2O3(20)	36g	0.6	1800s
3	SiO2(50)-CaO(30)-Al2O3(10)-Fe2O3(10)	36g	0.6	1800s

Table IV: Weight change before and after melting (Co)

No	Specimen weight Before/After	Co in specimen	Co in slag	Slag weight Before/After
1	356.7g / 352.9g	1.39g	0.185g	72g / 85.2g
2	355.1g / 352.1g	1.10g	0.114g	36g / 53.9g
3	356.4g / 352.5g	1.43g	0.033g	36g / 50.4g

Table V: Weight change before and after melting (Cr)

No	Specimen weight Before/After	Cr in specimen	Cr in slag	Slag weight Before/After
1	364.8g / 358.0g	2.33g	1.65g	72g / 92.1g
2	362.3g / 356.2g	2.09g	1.91g	36g / 55.3g
3	362.9g / 356.8g	2.09g	1.93g	36g / 48.2g

After separating the molten metal and slag, we analyzed the weight percent of Co and Cr nuclides in the slag by XRF and calculated removal rate of coated nuclides using the equation (1). The results are as shown in Table VI.

$$D(\%)=m(g) / M(g) \times 100 \quad (1)$$

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

Table VI: Removal rate of Co and Cr nuclides

No	Co			Cr		
	m(g)	M(g)	D(%)	m(g)	M(g)	D(%)
1	0.185	1.39	13.3	1.65	2.33	70.8
2	0.114	1.10	10.3	1.91	2.09	91.3
3	0.033	1.43	2.3	1.93	2.09	92.3

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3. Conclusions

Through this study, we carried out field investigation and nuclide analysis of thermal insulation which wrapped up RCS Loop of KORI Unit 1. And decontamination experiments for Co and Cr nuclides by induction melting were also carried out and got 2.3 ~ 13.3% removal rate of Co and 70.8 ~ 92.3% removal rate of Cr. In the future, we will keep going to experiment for increasing removal rate of Co and also for volume reduction of glass wool by incineration.

REFERENCES

[1] Tae-Hyeong Kim, Jeng Bo Yoo, Chang Je Park, Hong Joo Ahn, Kwang Yong Jee, Prospects and Status of Chemical Separation of Radionuclides form Decommissioning Radioactive Waste in Korea, Koran Nuclear Society, 2017.