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Study On Treatment Technology Using Plasma Torch Melting Facility for Heat Insulation Material (Perlite)

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1. Introduction

Many studies have been conducted on the treatment method of radioactive waste during the operation and dismantling of nuclear power plants. Among them, the plasma torch melting method is considered for treating radioactive waste. According to IAEA TECDOC-1527(2006), the technology can be applied to radioactive wastes of its type [1, 2]. The treatment method of perite used in the insulation material and piping insulation material of nuclear power plants was tested. In this study, the integrity of operation of the 100 kW plasma torch melting facility is reviewed.

To review the melting and discharge status of perite sample waste, 100 Kw plasma torch melting facility is used. Finally, the volume reduction ratio of the perite sample waste is reviewed.

2. Experimental

2.1 100kW plasma torch melting facility of KHNP CRI

As shown in Fig. 1, the 100kW plasma torch melting facility is mainly consist of melting chamber, pyrolysis chamber, slag discharge device, waste feeding system and off-gas treatment system. Especially, overflow method according to the level of molten is applied as a discharging device. In addition, to treat a variety of waste types, two feeding devices such as pusher and spray nozzle are installed.

Fig. 1. Picture of 100kW plasma torch melting facility

2.2 Target waste

Perite generated during power plant operation and dismantling was selected as a simulation sample. Table 1.1 shows the average chemical composition and ratio of perite in a domestic nuclear power plant. The particle size of the perite simulation sample for the demonstration test was pretreated to be less than 1 cm. Fig. 2 is a photograph of the pretreated perite sample waste.

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Table I: Composition of target waste(perlite)

in wt.%

SiO_2	Al_2O_3	Na_2O	K_2O	Fe_2O_3	CaO	MgO
70.3	9.7	10.0	3.4	1.2	1.6	0.8

Fig. 2. Picture of target waste(perlite)

3. Results and discussion

3.1 Development of slag composition

In order to treat the concrete waste in plasma torch melting system, various factors could be considered like the slag of electric conductivity, viscosity and melting temperature. In the previous experiment, it was confirmed that the viscosity of the molten waste could be improved through an additive. As a sample for the simulation test, an additive(CaO) was added for the purpose of improving the basicity. The slag composition developed is summarized in Table II. The composition consists of 50% perlite, 50% CaO.

Table II: Composition of developed slag composition

Items	Perlite			CaO
Proportion(%)	50.0			50.0
Composition	SiO_2	Al_2O_3	Na_2O	CaO
Proportion(%)	38.7	5.4	5.9	50.0

3.2 Demonstration test

In this demonstration test, as the main variables of the plasma torch melting facility, the distance, current, voltage, etc. between the torch and the melt can be considered, and the range of variables according to the operation mode in this test is shown in Table 3.
For the 95 kW output, nitrogen gas was used. The temperature of the Melting Chamber was about 1600℃ degrees. The throughput of the simulated samples of the plasma torch melting facility is 6kg and 7kg per hour. The total amount of the put-in perlite simulation sample weight is 65 kg. The operating time is 24 hours.

Table III: the range of variables by operation mode

Mode / Parameter range	Non-trasfer mode	Transfer mode
Torch distance	60 ~ 120	100 ~ 170
Ampere	140 ~ 180	130 ~ 140
Voltage	473 ~ 612	663 ~ 742
Power	70 ~ 96	95 ~ 103

3.3 Melt and discharge

In the non-transfer mode and transfer mode, the existing solidified sample remaining in the melting furnace was melted to make a molten pool. After confirming the temperature at which the flow field is made by the plasma torch gas (1050℃), the molten pool was melted by injecting a perlite simulation sample per 6kg and 7kg hour. The test sample is not discharged immediately after melting, and a dam is formed at the outlet of the melting furnace, and Figure 3 shows that the dam is formed without discharging the molten material. By continuously inputting the sample and applying the plasma output, finally the molted waste dam is collapsed.

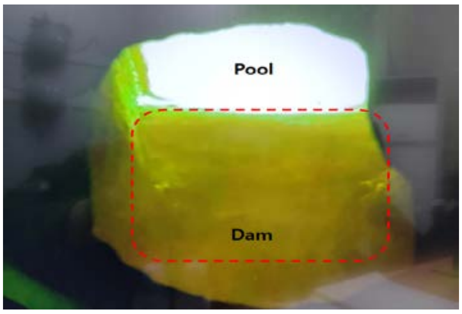

Fig. 3. Melting pool and dam

3.4 Volume reduction ratio

The result of measuring the weight of the input sample and the weight of the discharged sample, as shown in Table Ⅳ, the total input amount was 65 kg, while the total discharge amount was 63.8 kg, a weight difference of about 1.2 kg was confirmed. Finally confirming the reduction of about 95%.

Table Ⅳ: Input and output volume measurement

	Input	Output
Mass(kg)	65.00	63.80
Volume(ℓ)	481.00	23.05
Density(kg /ℓ)	0.14	2.78
Specific volume(ℓ/ kg)	7.40	0.36
Specific volume change amount	7.04	
Volume reduction ratio(%)	95	

4. Conclusion

To treat the various types of radioactive wastes, 100kW plasma torch melting facility was developed in KHNP CRI. The perite sample(65kg) was continuously operated for 19 hours using a 100 kW plasma torch melting facility. and the plasma arc power was melted and discharged without interruption. In this study, it was confirmed that a 50:50 ratio sample of perite and additive CaO was successfully molten and discharged. An extra review should be carried out to compare the melt and discharge viscosity by changing the ratio of the sample and the additive CaO.

REFERENCES

[1] IAEA, "Application of Thermal Technologies for Processing of Radioactive Waste", IAEA TECDOC-1527, 2006.
[2] Eduardo S. P. Prado, et al., "Thermal plasma technology for radioactive waste treatment: a review", Journal of Radioanalytical and Nuclear Chemistry, Vol. 325, p.331-342, 2020.