Evaluation of Applicability of 100kW Plasma Torch Melting Facility for Radioactive Waste Treatment

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1. Introduction

Plasma torch melting has been considered as a promising treatment technology for radioactive waste generated by nuclear power plants. According to IAEA TECDOC-1527(2006), the technology can be applied to radioactive wastes regardless of its type [1, 2]. Also, the technology has the advantage of less harmful gases such as NO_x, SO_x, HCl and CO because it does not use fossil fuels. To treat the various wastes such as concrete, harmful liquid and mixed wastes, 100kW plasma torch melting facility was designed and developed in KHNP CRI.

In this study, a demonstration test with concrete as a simulant was performed to evaluate the applicability of the technology using 100kW plasma torch melting facility.

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

The concrete waste, which is expected to be generated a lot during nuclear power plant of dismantling, was selected as the target waste. The chemical composition is summarized in Table I.

For the demonstration test, concrete waste was shredded to a size of 1cm by 1cm as a pretreatment as shown in Fig. 2.

Table I: Composition of target waste(concrete)

in wt.%

SiO_2	Al_2O_3	CaO	K_2O	FeO	Na_2O	MgO
64.7	14.7	9.8	3.3	3.2	3.1	1.2

Fig. 2. Picture of target waste shredded.

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. Above all, as a critical factor, the viscosity of the melt is very important to easily discharge the melt. The viscosity of slag (SiO_2-CaO-Al_2O_3 system) can be lowered by adding a basic oxide such as CaO, Na_2O, MgO and MnO, because the oxides carry out a role to break the network of SiO_2.

In this study, the basicity for plasma melting was calculated using a slag viscosity prediction model. As the result, the waste was mixed with additive materials, and then the melting test of the mixed waste was conducted to confirm the molten shape and viscosity using electric box furnace.

The slag composition developed is summarized in Table II and Fig. 3. The composition consists of 64% concrete, 23% CaO, 7.7% iron and 3.8% carbon. Melting test of target waste was conducted with additive materials. the target wastes were melted at 1,400℃ for 2 hours as shown in Fig. 4. When only concrete was melted, foaming occurred due to high viscosity. On the

other hand, when an additive material was added without foaming.

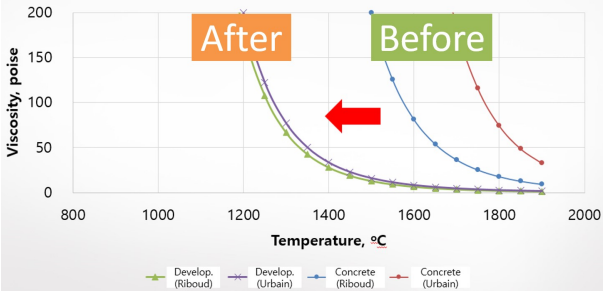

Fig. 3. Results of the viscosity of target waste.

Table II: Composition of developed slag composition

in wt.%

SiO_2	Al_2O_3	CaO	K_2O	FeO	Na_2O	MgO	Fe+C
42.3	9.6	29.5	2.2	2.1	2.0	0.8	11.5

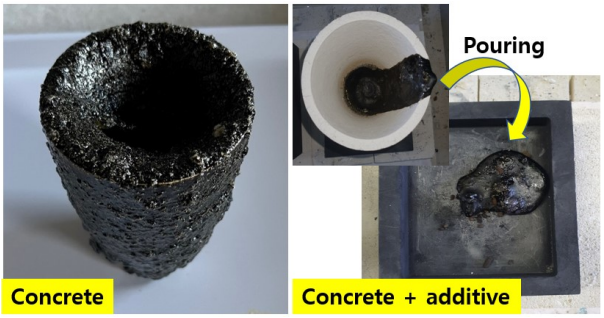

Fig. 4. Picture of melted concrete: (left) only concrete (right) concrete with additive.

3.2 Demonstration test

In this demonstration test, the integrity of 100kW plasma torch melting facility was evaluated for about 3days. The throughput of target waste is 1 to 15kg per hour using a push type feeding device. As shown in Table III, during the operation of 100kW plasma torch, the power was maintained about 95kW. The total amount of treated wastes is 212kg. According to the results of this test, the possibility of long-term operation of 100kW plasma torch melting facility was confirmed, and its applicability to waste treatment was evaluated.

Table III: Results of the demonstration tests

Plasma torch	Power	About 95kW
	Gas	N_2
	Mode	Transfer
Melting chamber	Temp.	About 1,600℃
Amount of treated waste	-	212kg
Operation time	-	72 hours

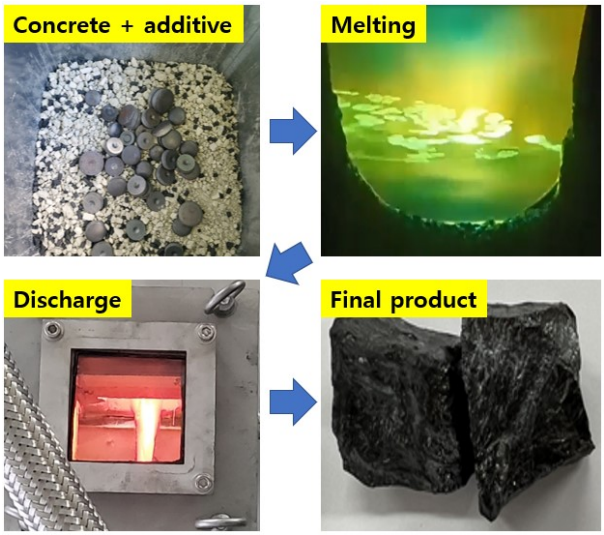

Fig. 4. Process of demonstration test of concrete waste

4. Conclusion

To treat the various types of radioactive wastes, 100kW plasma torch melting facility was developed in KHNP CRI. The applicability of plasma torch melting to concrete waste was successfully confirmed through development of slag composition and demonstration test for 3 days. However, it is considered that an additional review of the disposal for final products generated by plasma melting should be conducted.

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.