Study on Induction Melter Technology to Treat Decommissioning Metallic Radwaste Generated From Kori Unit 1

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1. Introduction

Development of metallic radwaste melting technology has been pursued actively since the 1960's and has become the technology for processing of metallic radwastes generated at the time of operation and decommissioning of nuclear facilities with the construction of commercial scale facilities for melting of metallic radwastes since the 1990's [1-2]. The majority of the radwastes generated at the time of the decommissioning of Kori Unit 1 are metals with approximately 86%. Among metallic radwaste, about 59% will be very low level (VLL) that can be recycled in the nuclear industry. In particular, there is a need for enhancement of the economic feasibility of the decommissioning industry through the reduction of disposal volume through recycling in the case of VLL metallic radwaste. In this study, the current status of the induction melter technology that is being applied most widely among the diverse range of melter technologies for the processing, volume reduction and recycling of the metallic radwaste was examined and the possibility of application of this technology to the decommissioning industry for Kori Unit 1 was considered.

2. Induction melter technology

2.1 General principle

Induction melter melts the metals inserted into the ceramic body by generating Joule heat with induced current generated through current flowing in the induction coil that surrounds the ceramic body.

Induction melter is composed of ceramic body, induction coil, discharge outlet (spout), hood and tilting device, etc. as shown in Fig. 1.

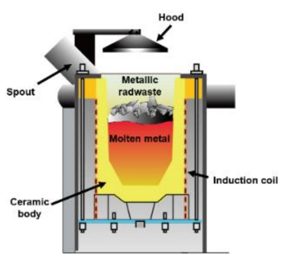

Fig. 1. Schematic diagram of induction melter.

2.2 Advantages and disadvantages of induction melter

Advantages of the induction melter includes ease of discharge since the tilting method is applied after having melted metal, ability to minimize the generation of exhaust gas in comparison to other melting methods as well as spontaneous heating and stopping. Disadvantages include difficulties in treatment of metal with a high level of radiology since the sealing of the top portion of the melter is not easy, ability to melt only metals and concerns for steam explosion if the metal being melted contains moisture. Moreover, if hard bridging is created due to the accumulation of slag on top of the molten metal, there is possibility of leakage of melted substance and explosion of the smelting furnace due to the loss of control because of the presence of accumulated slag.

2.3 Status of overseas and domestic

The USA, Germany, Sweden, England, France, Russia and Korea have been operating metallic radwastes processing facilities for various metallic radwastes including carbon steel (CS), stainless steel (STS), aluminum and copper since 1992. Among these countries, Germany and Sweden are known to operate their facilities exemplarily. KNF in Korea has been collecting the radioactive substance through slag by melting metallic radwastes and executing clearance level disposal for the remaining molten metal since 2011. The performances of the treatment by facilities in overseas countries and Korea are summarized in the Table 1.

Table 1. Treated amounts at each facility

Owner/Facility (Country, Starting year)	Target wastes	Capacity (ton/batch)	Products
EnergySolutions (USA, 1992)	CS, STS, Aluminum	20	Ingot, shielding block, waste container
CARLA (Germany, 1989)	CS, STS, Aluminum, Copper, Lead	3.2	Ingot, shielding block, waste container
STUDSVIK (Sweden, 1987)	CS, STS, Aluminum, Brass, Copper, Lead	3.5	Ingot, shielding block
Capenhurt (England, 1994)	Aluminum, Brass, Copper	4	Ingot
CENTRACO (France, 1999)	CS, STS, etc.	4	Ingot, tube
ECOMET-S (Russia, 1994)	CS	2.5	Ingot
KAERI (Korea, 2013)	CS, STS	0.35	Ingot
KNF (Korea, 2011)	CS, STS	0.25	Ingot

*CS : carbon steel, **STS : stainless steel

3. Consideration of application

In the event of considering the installation of induction melter for the processing of metallic radwastes generated at the time of decommissioning of Kori Unit 1, various aspects including operating conditions, key components and capacities, and layout plans, etc. were considered.

3.1 Condition of operation

The condition of operation for the induction melter is as follows (Table 2).

Table 2. The condition of operation

Throughput	Melting for 45min, drainage for 15min
# of melters	2ea
Operation method	One is in operation and the other one is charging and heating mode
Power supply	Dual type inverter
Drainage method	Tilting type
Required area for installation	About 100m^2
Power requirement	About 1.5MW

The evaluated power requirement is estimated based on the below information (Table 3).

Table 3. The evaluated power requirement

Caloric requirement for raising of temp. to 1,550^{o}C for CS	About 354,500kcal/ton (i.e., 412kWh/ton, 1kWh=860kcal, 1kcal=0.00116279kwh)
Applied energy transformation efficiency	About 65%
Melter transformation efficiency	412kWh/ton/0.65=634kWh/ton
Required electricity capacity	634kWh/tonx1.5ton/h x60min/45min=1.27MW (about 20% surplus consideration : 1.5MW)

3.2 System configuration

Floor plan and frontal view of the layout plan for 1.5MW induction melter for the processing of metallic radwastes at the time of decommissioning of Kori Unit 1 are illustrated in the Fig. 2.

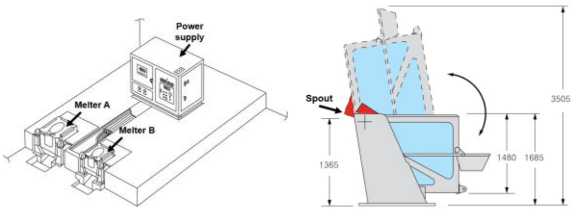

Fig. 2. (a) System arrangement for dual induction melter and (b) tilting type induction melter.

4. Conclusions

Evaluation was made on the 2 units of induction melter equipped with the dual type inverter power supply capable of processing 1.5 tons of carbon steel per hour, and the method of their application was established to process metallic radwastes generated at the time of decommissioning of Kori Unit 1. Induction melter is being used most widely throughout the world and its performances have been proven. Accordingly, it is most appropriate for processing of metallic radwastes. In the case of Kori Unit 1, it is necessary to process metallic radwastes decommissioning within approximately 5 years. Accordingly, it is desirable to install dual units in order to elevate the processing rate. However, although it is determined that there would not be any difficulty in the case of very low level radwastes, it is necessary to determine in the near future whether it can be applied to low level radwastes with a relatively higher level of radioactivity.

REFERENCES

[1] KHNP CRI, "Study on Commercialization Measures for Treatment of Large Metallic Radwaste", Technical Report (2013).

[2] KHNP CRI, "Feasibility Study on Treatment and Recycling for Radioactive Metal Waste", Technical Report (2014).