Evaluation on Glass Mold Integrity of Cold Crucible Induction Melter for Discharging Glass Melt

Sunghoon Hong[a*], Seok-Ju Hwang[a], Cheon-Woo Kim[a], and Toshiro Oniki[b]
[a]KHNP CRI, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, Republic of Korea
[b]IHI Yokohama Engineering Center, Kanagawa 235-8501, Yokohama-shi, Isogo-ku, Shin-Nakahara-cho, Japan
[*]sunghoon.hong@khnp.co.kr

1. Introduction

Vitrification using the CCIM (Cold Crucible Induction Melter) is considered as one of promising radioactive wastes treatment technology [1]. Vitrification technology is to incorporate radioactive nuclides in the stable glass matrix as radioactive wastes are fed on the molten glass. Accordingly, release of radioactive nuclides to the environment at the disposal site can be fundamentally prevented.

Currently, in the KHNP CRI, with CCIM with 85 cm diameter, vitrification demonstration test has been conducted to confirm the possibility of treatment of liquid wastes. Also, the various operation parameter which produced by the demonstration test are analyzed for the design data of commercial facility. Among of the various operation parameter, glass mold of temperature including cooling rate is one of the vital value to form the glass structure on the vitrification process. Also, the temperature could induce diverse problems such as thermal deformation, thermal degradation and etc. of the glass mold.

Therefore, in this study, the temperature recording system is installed to continuously measure the glass mold temperature during the glass melt discharge. The temperature measured is discussed in view of the integrity of glass mold.

2. Experimental

2.1 System of vitrification plant of KHNP CRI

The virtification process developed by the KHNP CRI consists of loading glass, startup for melting glass, feeding and vitrifying and draining as shown in the Fig. 1. The CCIM with 85 cm diameter is a water-coolded melter in which electrical currents are directly induced in the glass melt from an external high frequency generator (HFG). The HFG with Metal Oxide Semiconductor Field Effect Transistor (MOSFET) invertor provides induction power of up to 600 kWe at a nominal frequency of 250 kHz [2].

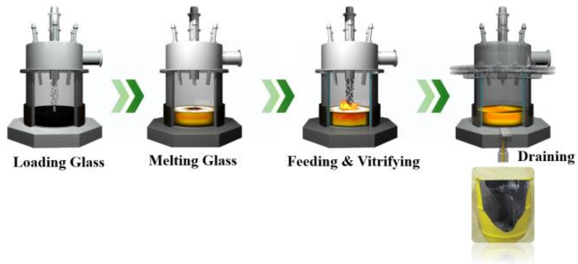

Fig. 1. Vitrification process by using CCIM [2].

2.2 Operation data of demonstration test

The operation data of demonstration test using a slurry feed is summarized as shown in Table. 1. The Slurry and glass frit were fed into CCIM and a borosilicate glass melt was formulated and discharged.

Table 1. Operation data of demonstration test

Time	Event	Remarks
11:16	HTF on	
11:26	Start the ignition of Ti-ring	3 'o clock direction
13:46	Temp. of glass melt - Upper : 1141 ℃ - Middle : 840 ℃ - Bottom : 558 ℃	
14:00~ 14:30	Slurry feed rate @ 20 ℓ/hr	Amount of feed -Liquid waste : 390 ℓ -Glass frit : 107 kg
14:30~ 15:00	Slurry feed rate @ 50 ℓ/hr	
15:00~ 18:00	Slurry feed rate @ 85 ℓ/hr	
18:00~ 19:00	Slurry feed rate @ 100 ℓ/hr	
19:00~ 19:20	Mixing glass melt	
19:28~	Start the discharge	Amount : 224 kg
19:48	HFG off	

2.3 Specification of glass mold

Glass mold which made of stainless steel 304 is used for discharging. To measure the history of temperature during glass discharging, eight of thermocouple guides (bottom: 2, side: 6) were attached as shown in the Fig. 2. For good contact between thermocouple and glass mold surface, regardless of thermal expansion, the guide applies the spring fixing method as shown in the Fig. 3. Also, K-type thermocouple is used with the temperature recorder GL240 (GRAPHTEC Co.).

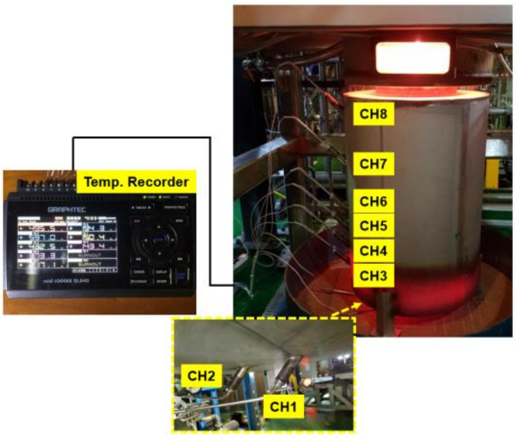

Fig. 2. Temperature recording system for the glass mold.

Fig. 3. The spring guide for fixing thermocouple.

3. Result and Discussion

During the glass melt discharge, the temperature of glass in the mold is continuously measured by the temperature recording system. The system receives signals from eight of channels where two are on the bottom (CH1, 2) and the others are on the side (CH3, 4, 5, 6, 7, 8).

Fig. 4 shows the temperature profile of glass mold for discharge. Molten glass is drained for 20 min (started at 07:28 pm and finished at 07:48 pm). The maximum temperature of glass mold is about 700 °C at the bottom center (CH1) after 30 minutes of discharge. Accordingly, the integrity of glass mold could be maintained (melting point of stainless steel 304 : 1400 ~ 1450 ℃).

Table. 2 summarized the temperature history which the temperature was cooled down by room temperature (~25 ℃). The time to spend from maximum temperature to room temperature is 2751 minutes (47 hr 51 min).

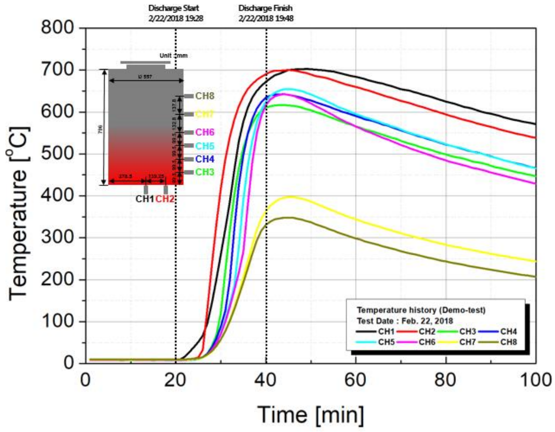

Fig. 4. Temperature history of mold for glass discharge.

Table 2. Temperature history at CH1 (bottom center of mold)

Time	Mold surface Temp. at CH1	ΔTime (min)	Remarks
19:28	8.7 ℃	0	Start discharge
19:48	662.7 ℃	20	Finish discharge
19:58	703.2 ℃	30	Max. Temp.
20:37	600 ℃	69	
21:22	500 ℃	114	
22:32	400 ℃	184	
00:25	300 ℃	295	
04:10	200 ℃	520	
12:55	100 ℃	1045	
10:21	30 ℃	2331	
17:51	25 ℃	2781	Cool down completely

4. Conclusion

The temperature profiles were measured at eight different positions of STS mold. The glass mold shown the excellent integrity, i.e., no deformation and degradation during the glass melt discharge. Additionally, the glass produced is being investigating in view of the micro-structure.

REFERENCES

[1] C.W. Kim, et al., “Chemically Durable Iron Phosphate Glasses for Vitrifying Sodium Bearing Waste (SBW) Using Conventional and Cold Crucible Induction Melting (CCIM) Techniques”, Journal of Nuclear Materials (2003).

[2] C.W. Kim, “Vitrification Technology for Radioactive Waste Treatment”, Korea Atomic Industrial Forum (2011).