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Development of High-Temperature Transport System for Molten Salt in Pyroprocessing

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1. Introducton

Pyroprocessing technology is a promising technology for many advanced fuel cycle scenarios with favorable economic potential and intrinsic ploliferation-resistance [1,2]. The pyrochemical process, which has been under development by the Korea Atomic Energy Research Institute (KAERI) since 1997, consists of processes such as pre-treatment, oxide reduction, electrorefining, electrowinning, and waste salt treatment.

The electrorefining process, which is a key process in pyroprocessing, is composed of two parts, electrorefining to deposit a uranium with a solid cathode and electrowinning to co-deposit TRU and RE with a liquid cadmium cathode (LCC).

As the electrorefining operation proceedes, TRU and RE are accumulated in electrolyte LiCl-KCl salt, and after the electrorefining process, the molten salt used in an electrorefining reactor should be transported to the next process, the electrowinning process, to recover U/TRU/RE; Thus, a molten salt transfer system by suction is now being developed. An apparatus for suction transport experiments was designed and constructed for the development of high- temperature molten salt transport technology. Suction transport experiments were performed using LiC-KCl eutectic salt.

The feasibility of pyro-reprocessing has been demonstr ated through many laboratory-scale experiments. In pyroprocessing, a eutectic LiCl-KCl salt was used as a liquid elextrolyte for a recovery of actinides. However, reliable transport technologies for these high temperature liquids have not yet been developed. A preliminary study on high-temperature transport technology for molten salt by suction is now being carried out.

In this study, three different salt transport technologies (gravity, suction pump, and centrifugal pump) were investigated to select the most suitable method for molten salt transport. An apparatus for suction transport experiments was designed and installed for the development of high-temperature molten salt transport technology.

Basic preliminary suction transport experiments were carried out using the prepared LiC-KCl eutectic salt at 500℃ to observe the transport behavior of LiCl-KCl molten salt. In addition, a PRIDE salt transport system was designed and installed for an engineering-scale salt transport demonstration.

2. Experiment

An experimental apparatus was constructed and install ed for the suction transport experiments. The apparatus used for the suction transport experiments consists of two reactors (melting and receive) and a transport tube with a heating furnace, a vacuum chamber and pump, and a control panel. The experimental apparatus is installed within the glove box owing to the material causticity of salt. Several types of suction transport experiments were performed using the prepared LiC-KCl eutectic salt. The experimental apparatus is shown in Fig. 1.

Fig. 1. Apparatus for suction transport experiment

For the basic suction transport experiments, LiCl-KCl eutectic salt was prepared by mixing and drying 99.0% purity LiCl and KCl, at a weight ratio of LiCl (44.8wt%) and KCl (55.2wt%) because high purity 99.999% LiCl-KCl eutectic salt is very expensive. Basic suction transport experiments to observe the transport behavior of molten salt were then carried out using the prepared LiC-KCl eutectic salt under a vacuum range of 100mtorr to 10torr at 500℃.

In addition, a PRIDE salt transport system was designed and installed in an Ar cell, the second PRIDE facility for an engineering-scale salt transport demonstrat- ion, and its performance was confirmed.

3. Results and Discussion

3-1. Lab-scale experiments

Three different salt transport technologies (gravity, suction pump, and centrifugal pump) were investigated. the suction pump transport method was selected as a method for high-temperature molten salt transport in KAERI owing to its flexibility.

Based on the results of a TGA analysis using 31mg of prepared LiCl-KCl eutectic salt, as shown in Fig. 2, the

drying condition for preparing the LiCl-KCl eutectic salt was determined as 200℃ for 1hr.

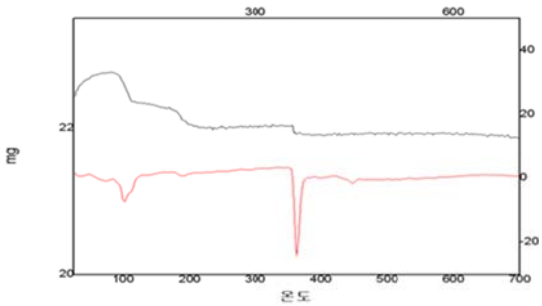

Fig. 2. TGA analysis results of prepared LiCl-KCL eutectics
[——: Weight (mg), ——: Heat Flux (mW)]

As a preliminary study for the development of high-temperature transport technology for LiCl-KCl eutectic molten salt, several suction molten salt transport experiments were carried out.

From the experimental results, about 1.82 kg of salt was transported through the transport tube from the melting reactor to the receive reactor. Considering the residual salt, about 0.18 kg at the bottom of the melting reactor owing to the conical type of melting reactor, most of the molten salt, over 99%, in the melting reactor was transported by the suction transport method. The transported salt in the salt mold vessel is shown in Fig. 3.

Fig. 3. Transported salt in the mold vessel

The experimental results of lab-scale molten salt transport by suction showed a 99.5% transport rate (ratio of transported salt to total salt) under a vacuum range of 100 mtorr to 10torr at 500℃. The results of molten salt transport experiments under a vacuum range of 200 mtorr to 10torr at 500℃via suction time are shown in Fig. 4. The mass flow rate via suction time is 1.54kg/min.

3-2. PRIDE salt transport system

The PRIDE(PyRoprocessing Integrated inactive Demonstration facility) salt transport system is an apparatus to transport the used salt in an ER reactor to an electrowinner to recover TRU and RE after a champaign of electrorefining operation. This system is composed of a salt ingot manufacturing apparatus, a salt ingot separation apparatus, and a salt ingot charging /transport apparatus as shown Fig 5.

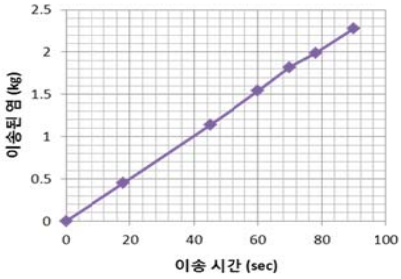

Fig. 4. Experimental results under several conditions

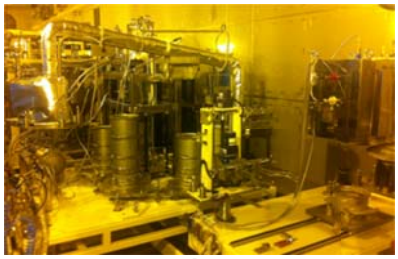

Fig. 5. PRIDE salt transport system

4. Conclusions

Several types of suction transport experiments using molten salt (LiCl-KCl eutectics) for the development of a high-temperature molten salt transport technology were carried out. The experimental results of lab-scale molten salt transport by suction showed a 99.5% transport rate under a vacuum range of 100mtorr to 10torr at 500℃. From the results of molten salt transport experiments under a vacuum range of 200 mtorr to 10torr at 500℃ via suction time, the mass flow rate via suction time is 1.54kg/min.

To establish engineering- scale salt transport technology,a PRIDE salt transport system was designed and installed in an Ar cell, the second PRIDE facility for engineering-scale salt transport demonstration, and its performance was confirmed.

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