

Principal Research Results

Development of Novel Electrorefiner with High Temperature Liquid Transports for Pyrochemical Reprocessing of Nuclear Fuels

Background

Due to the potential advantages in nuclear proliferation resistance, reduction of waste burden and economy, pyrochemical reprocessing is being focused in many countries such as USA, Japan, Korea, India and China for realizing fast reactor fuel cycle. In Japan, pyrochemical reprocessing has been studied by CRIEPI and JAEA as sub-concept in the framework of FaCT project operated by JAEA and utilities. Feasibility of pyrometallurgical reprocessing has almost been convinced through many laboratory scale experiments. Hence development of the engineering technologies for industrialization and engineering model with high throughput are current key issues. The most time-consuming operation to be reduced in electrorefining step is to move the products, the electrodes, and the molten salt electrolyte to next processes because it is necessary to pre-heat and to cool down before and after each movement. The new concept of an electrorefiner connected with a salt treatment system and a distillator was proposed as shown in Fig.1.[ref] In this study, demonstration of scaled-up electrorefiner with practical processing rates was carried out based on the development of transport technologies of molten salt and liquid metal.

Objectives

The purpose of this study is to develop the reliable transport technologies for high temperature molten salt and liquid cadmium. The study also aims to demonstrate the feasibility of novel electrorefiner with non-radioactive simulant.

Principal Results

1. Transport technologies for molten salt and liquid metal

In pyrochemical reprocessing, eutectic LiCl-KCl salt (m.p.=352 °C, density=1.7 g/cm³) and cadmium (m.p.=348 °C, density=7.8 g/cm³) will be used as liquid media for recovery of actinides. As the reliable transport technologies applicable to these high temperature liquids were not developed yet, basic experiments to observe transport behavior were carried out as shown in Fig. 3. Then transport equipments to test the applicability of possible technologies such as a centrifugal pump, a suction pump and gravity were designed and installed in the large-scale argon atmosphere glove box shown in Fig. 2. Installed molten salt transport test rig is shown in Fig.4.

- (1) Transport of molten salt: By repeating the tests with pure molten salt of about 500 °C, controllability in practical flow rate, 1 - 3 L/min, was demonstrated for both gravity transport and centrifugal pump transport. In order to evaluate the applicability of the transport technologies for the molten salt dispersed with insoluble FP fines, same transport tests were carried out with the molten salt slurry (molten salt and SS fines mixture). Transport of molten salt slurry was demonstrated for gravity transport, and the equation to predict minimum flow velocity necessary for transport of molten salt slurry was proposed.
- (2) Transport of liquid cadmium: By repeating the tests with liquid Cd of about 500 °C, controllability in practical flow rate, 1 - 3 L/min, was demonstrated for gravity transport, centrifugal pump transport and suction transport.

2. Demonstration of novel electrorefiner

Engineering-scale electrorefiner, 780 mm of int. dia. and 800 mm of depth, with liquid Cd transport to the distillator was designed and installed as shown in Fig. 5. With using gadolinium as plutonium stimulant, integrated test to demonstrate the recovery of gadolinium through electrorefining and distillation was carried out. The obtained recovery ratio and the throughput were high enough to demonstrate the feasibility of the novel electrorefiner.

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Future Developments

Long term stability test of the transport system and optimization of electrorefiner design will be carried out.

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Reference

T.Koyama, et.al., 2007, "Development of Engineering Technology Basis for Industrialization of pyrochemical reprocessing", proceedings of GLOBAL2007, Boise, US.

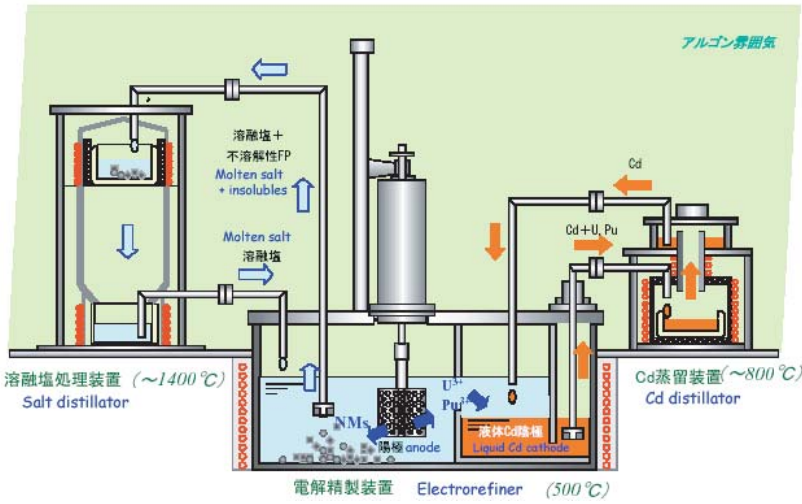


Fig.1 Novel electrorefiner with high temperature liquid transport.

Fig.2 Large-scale Ar glove box.



Fig. 3 Gravity transport test with molten salt.

Fig.4 Molten Salt Transport test Rig.

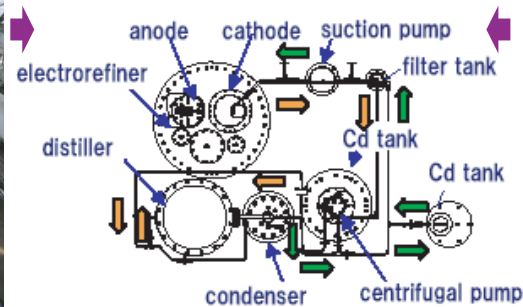


Fig.5 Photos and plain view of engineering-scale electrorefiner with liquid Cd transport to the distillator.