# Development of an integrated crucible for the salt separation

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## 1. Introduction

Pyroprocessing has been developed for the recovery of actinide elements from spent fuel due to its advantages. Electrorefining is a key step in pyroprocessing. The electrorefining process is generally composed of two recovery steps – the deposit of uranium onto a solid cathode and the recovery of the remaining uranium and TRU elements simultaneously by a liquid cadmium cathode. The solid cathode processing is necessary to separate the salt from the cathode since the uranium deposit in a solid cathode contains electrolyte salt.

A physical separation process, such as distillation separation, is more attractive than a chemical or dissolution process because physical processes generate much less secondary process. Distillation process was employed for the cathode process

sing due to the advantages of minimal generation of secondary waste, compact unit process, simple and low cost equipment [1,2]. The basis for vacuum distillation separation is the difference in vapor pressures between salt and uranium. A solid cathode deposit is heated in a heating region and salt vaporizes, while non volatile uranium remains behind [3].

It is very important to increase the throughput of the salt separation system due to the high uranium content of spent nuclear fuel and high salt fraction of uranium dendrites [4,5].

The evaporation rate of the LiCl-KCl eutectic salt in vacuum distiller is not so high to come up with the generation capacity of uranium dendrites in electro-refiner. Therefore, wide evaporation area or high distillation temperature is necessary for the successful salt separation.

In this study, the integrated salt separation system was developed to increase the throughput of the salt removal process by the separation of the liquid salt prior to the distillation of the LiCl-KCl eutectic salt from the uranium deposits

## 2. Experimental

The salt separation experiments were carried out on an integrated sieve-crucible assembly in distillation tower. Fig. 1 shows a sieve for the solid-liquid separation and a crucible for the integrated sieve-crucible assembly. The mesh opening was 150 μm.

The salt separation experiments were carried out in the vacuum distiller. The distiller was composed of a distillation tower with an evaporator and a condenser, a control unit, and an off gas treatment system. The diameter of the tower at an evaporation area was 400mm. The temperature in the crucible was measured by using a thermocouple that is connected to the centre of the tower.

## 3. Results and Discussion

The fraction of adhered salt in uranium deposits is more than 20 % [5]. Therefore, the capacity of salt distiller should be large enough. Kwon et al. proposed a method to reduce the burden of the distillation process by the liquid salt separation prior to the salt distillation [6]. In the method, the adhered salt is separated by heating on the sieve at low temperature compared to the operation temperature of vacuum distiller, and then the residual salt is evaporated in a salt distiller at an elevated temperature.

In this study, the integrated salt separation system was developed to combine a liquid salt separation column and a vacuum distiller into one distillation tower by using an integrated sieve-crucible assembly. The integrated sieve-crucible assembly is composed of a liquid separation sieve and a distillation crucible as shown in Fig. 1.

The salt separation procedures in the salt distillation tower are as following;

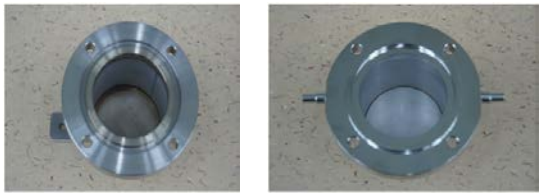
- Place an integrated assembly with uranium deposits (sieve downward)
- Separate liquid salt at low temperature
- Rotate the integrated assembly (crucible downward)
- Distillate salt

It was examined on the feasibility of the integrated sieve-crucible assembly by the rotation test of the assembly in the distillation tower. Fig. 2 shows an integrated sieve-crucible assembly placed on the mock top-flange of the vacuum distillation tower. The assembly was rotated when the guide bar was pulled up. The surrogate deposits in the sieve fall down into crucible.

It is very important to rotate the integrated sieve-crucible assembly without the impact of vacuum in the distillation tower. It was designed to protect a leak of air into the distillation tower during the guide bar operation. The space between the guide bar and the top flange was sealed by a double O-ring. The integrated

assembly was tested in the distillation tower as shown in Fig. 3. The assembly rotated successfully and the uranium deposits fall down from sieve to crucible. The leak of air was monitored using a vacuum pressure sensor. No air leakage was found during the test.

From the above results, it could be concluded that the salt can be separated by using an integrated sieve-crucible assembly.



(a) (b)

Fig. 1. Photographs of (a) a sieve for the solid-liquid separation and (b) a crucible for the integrated sieve-crucible assembly.

Fig. 2. Photograph of an integrated sieve-crucible assembly in the top flange of the vacuum distillation tower.

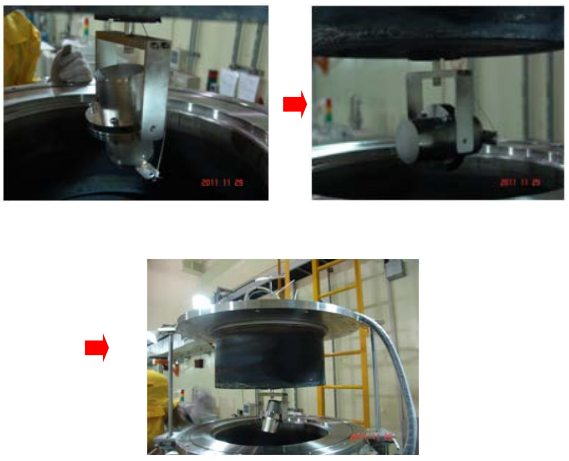


Fig.3. Rotation of the integrated sieve-crucible assembly in the salt distillation tower.

## 4. Conclusions

In this study, the integrated salt separation system was developed to increase a throughput of the salt removal process for the separation of the liquid salt and then the distillation of the LiCl-KCl eutectic salt from the uranium deposits. The integrated assembly is composed of a liquid separation sieve and a distillation crucible. It was found that the effective salt separation was feasible by the integrated sieve-crucible assembly in one distillation tower.

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