

Heavy Water Reactor(HWR) Spent Resin Mixture Processor Development

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1. Introduction

The liquid radioactive waste, generated in the process of operating NPPs (Nuclear Power Plants), is purified using the ion exchange resin. PHWR Wolsong Units 1 and 2, which are Pressurized Heavy Water Reactors, temporarily store spent resin in the spent resin storage tank, and they are planning to process it according to the NPP decommissioning plan.

The spent resin, generated by heavy water reactors, contains various radioactive nuclides, and especially because it has a high concentration of C-14, a long-lived nuclide, it is classified as ILW (Intermediate Level Waste) radioactive waste. The spent resin mixture in the storage tank contains about 20% of active carbon and zeolite, and about 80% of mixed resin.

This study developed a system for processing the spent resin mixture, stored in the spent resin storage tank of a heavy water reactor, and derived the optimal performance of the system by conducting an empirical experiment using actual spent resin. The authors analyzed the factors affecting the performance of the system, and reviewed the relationships between these factors and the performance of the system. The spent resin used for the empirical experiment was sampled from storage tank No. 2 of Wolsong Unit 1.

2. Methods and Results

2.1 Making the heavy water reactor spent resin mixture processor

Based on the results of a laboratory-size simulation, the authors designed a 1-liter batch-type closed circuit circulation process, and the spent resin mixture processor (Fig. 1) consisted of the spent resin separation, C-14 desorption and CO₂ adsorption part.

The spent resin mixture separator is a separation system using the particle size in the liquid state based on the results of the analysis of the characteristics of the spent resin mixture. To desorb C-14 from the separated resin, the direct heating technology using the microwave was applied, and magnetrons with 3kw power (1kw, 3ea) were used through the simulation. For CO₂ adsorption, a circulating adsorption system, including an adsorption tower with adsorbents, was made.

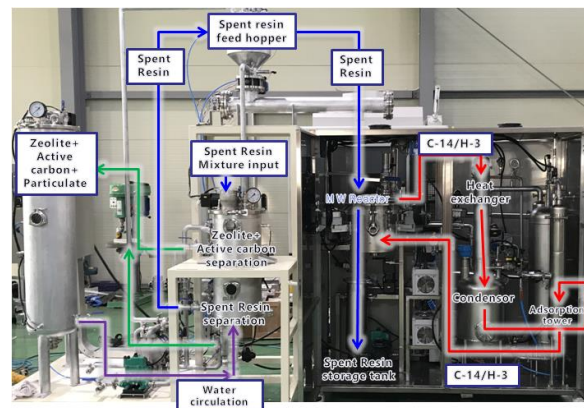


Fig. 1. Heavy water reactor spent resin mixture processor.

2.2 Separating the resin

The heavy water reactor spent resin mixture processor was used to separate resin from the spent resin mixture, and the optimal separation process was established. The spent resin separation procedure is shown in the process flow chart illustrated in Fig. 2 below.

- 1) Supply circulating water to the circulating water tank in ①.
- 2) Put the spent resin mixture in the separator in ②.
- 3) Use the line in ③ to supply circulating water to the separator.
- 4) Separate the spent resin while operating the impeller.
- 5) Retrieve the circulating water through the line in ④.
- 6) Re-supply the circulating water with the fine powder removed by the filter at the top of the tank in ① to the separator.
- 7) Discharge the separated active carbon and zeolite.
- 8) Re-supply the retrieved circulating water to the separator.
- 9) The separated spent resin will be stored in the buffer hopper along the line in ⑥.
- 10) The separated spent resin will be supplied to the MW reactor using the screw-type feeder in ⑧.

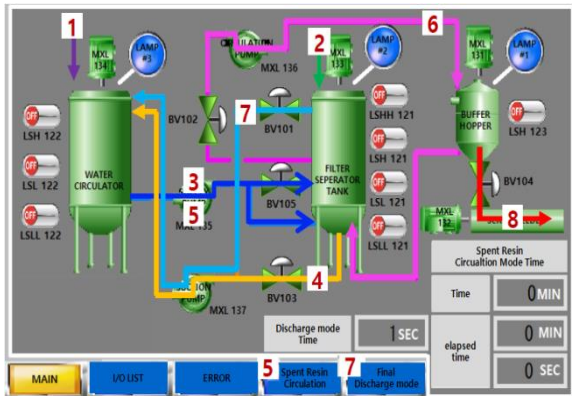


Fig. 2. Spent resin mixture separator process flow.

2.3 C-14 desorption

The separated spent resin will be supplied from the spent resin mixture separator to the microwave reactor, and desorbed according to the process in Fig. 3.

- 1) For effective reaction between the supplied resin and the microwave, the impeller (⑤) will be operated.
- 2) For circulation of the desorbed gas, the blower (⑥) will be operated.
- 3) To collect the moisture, the condenser (②) will be operated.
- 4) Desorbed C-14 will be transported to the adsorption tower along the line in ③.
- 5) To enhance the efficiency of C-14 adsorption, a closed circulation process was designed.

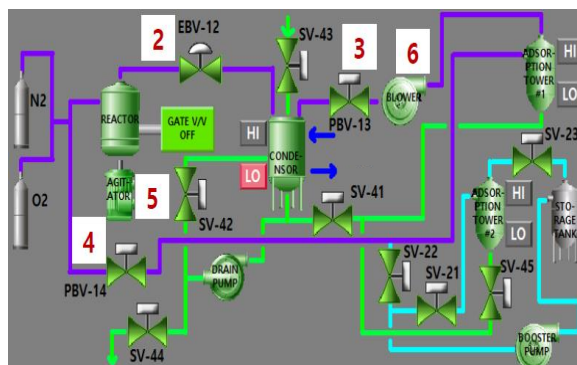


Fig. 3. Microwave C-14 desorption process flow.

2.4 CO₂ adsorption

C-14 in the C-14 desorption process will be adsorbed by the adsorption tower in 1. However, some unadsorbed C-14 will be collected in the storage tank, and the residual C-14 will be adsorbed by the adsorption tower through the circulation process. Inside the adsorption tower, there are six stages to increase the reaction surface area of the adsorbent and C-14, and Fig. 4 illustrates the interior of the adsorption tower.



Fig. 4. Image of the interior of the adsorption tower.

3. Conclusion

The authors developed a system for processing the spent resin mixture stored in the spent resin storage tank of the heavy water reactor, and derived the optimal performance of the system by using actual spent resin to conduct an empirical experiment.

To efficiently separate the spent resin from the spent resin mixture, appropriate meshes in consideration of the particle size of each component were selected, and to effectively transport the separated spent resin, appropriate flow and flux were determined. To improve the separation efficiency of each mixture with a different mass, the RPM of the impeller was adjusted, and to increase the resin feed rate, the optimal operation conditions of the diaphragm pump were derived.

To effectively desorb from the spent resin, the power supplied to the magnetron and the optimal reaction time were derived.

4. Acknowledgement

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