Development of the PHWR Spent Resin Treatment Technology to Secure Disposal Safety

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1. Introduction

The annual average amount of spent resin, generated by domestic PHWR (Pressurized Heavy Water Reactor) NPPs, is 72,520L for Wolsong NPP #1, and 52,040L for Wolsong NPP #2. As of December 2017, 362,600L and 260,200L of spent resin is stored in Wolsong NPP #1 and Wolsong NPP #2 respectively.

AS the currently stored spent resin has a high concentration of C-14, it is classified as intermediate-level radioactive waste, and must be disposed of in a rock cavern. As the total radioactivity of C-14 in the spent resin is about 10 times higher than the total limit of the underground repository cavern, however, C-14 in the spent resin must be removed to dispose of spent resin.

In this study, development of the spent resin mixture separation and C-14 removal technology for the currently stored spent resin to treating. And the method of recycling it was researched.

2. PHWR spent resin treatment technology

2.1 Spent resin treatment process development

The spent resin mixture, stored in the PHWR NPP, was divided into spent resin and other mixtures. The validity of disposal and deregulation of the other mixtures with relatively low radioactivity was reviewed. And then, C-14 was removed from the spent resin, classified as intermediate-level radioactive waste, and disposal suitability was secured.

The validity of recycling the removed C-14, which is an expensive resource, by adsorbing it and turning it into a labeled compound ($Ba^{14}CO_3$), which is used in the industry, was reviewed.

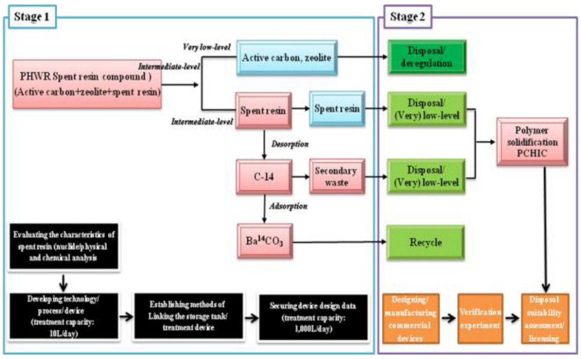

Fig. 1. PHWR spent resin treatment process.

2.2 Developing the spent resin mixture separation technology

Currently the spent resin, stored in the storage tank of the NPP is stored as a mixture of zeolite, active carbon and resin along with the stored liquid waste. Also, the mixture in the repository is solidly fixated depending on location.

The fixated parts are crushed with a crushing machine, and transferred to the buffer tank through the resin outlet.

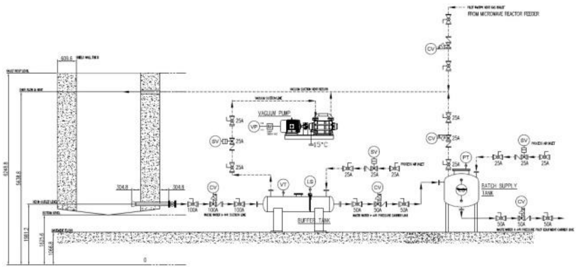

Fig. 2. Spent resin storage tank and transfer device.

10L of the spent resin mixture in the buffer tank is transferred at a time by the spent resin separating and sorting device. The transferred spent resin mixture goes through the multi-level mesh together with the supplied water, and is separated into zeolite and active carbon at the top, and spent resin at the bottom. The zeolite and active carbon at the top will return to the mixture recovery tank, and be contained in the disposal vessel. The separated spent resin at the bottom will be transferred to the resin supply tank at the top and stored there.

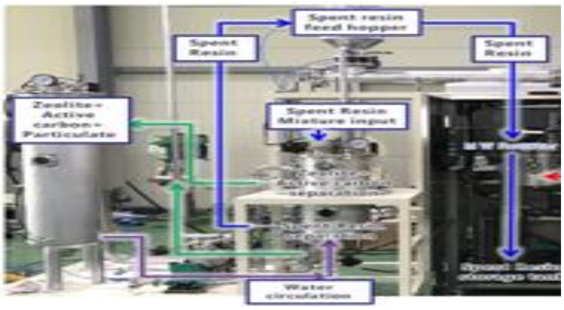

Fig. 3. Spent resin mixture separating and sorting device.

2.3 Developing the technology for desorbing /adsorbing the C-14 in the spent resin

2kg of spent resin is transferred from the spent resin supply tank to the microwave reactor at a time, and C-14 is desorbed. The hot gas, containing the C-14 generated after reaction will circulate the closed circuit, and the moisture is removed by the cooling tower in the downstream and passes the first multi-level adsorption tower, and is adsorbed by the charged adsorbent. This process is operated in a close-circuit circulation mode to increase the efficiency of adsorption. The C-14 gas, which remains after the circulation process, is stored in the compression tank in the downstream, and sent to the secondary multi-level adsorption tower for circulation.

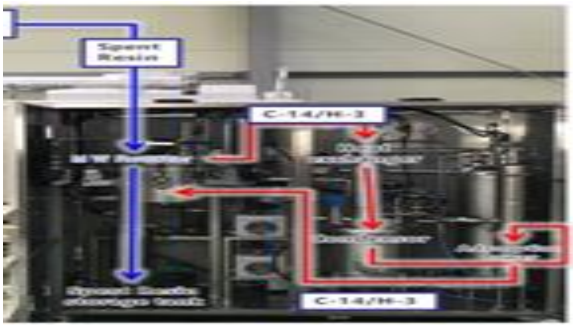

Fig. 4. A device for desorbing/adsorbing C-14 in the spent resin.

3. Verification experiment for the PHWR spent resin mixture treatment device

The PHWR spent resin mixture treatment devices, which was developed by this study, was used to conduct the verification experiment. The sample was the 20L of spent resin mixture collected from #2 tank of Wolsong NPP #1. It was used to separate the mixture and desorb/adsorb the C-14 in the spent resin. The experiment was conducted a total of 4 times under the conditions in Table 1. The optimal mixture separation and C-14 desorption/ adsorption conditions using the microwave were derived by conducting basic performance tests in the field before the verification experiment.

Table 1. Operating conditions by batch

Classification	Target specimen	Amount of injected mixture	Reactor injection
BATCH 1	manhole	7 L	2 kg
BATCH 2	manhole	4 L	2 kg
BATCH 3	manhole	4 L	2 kg
BATCH 4	testhole	2 L	2 kg

4. Securing a method of recycling the removed C-14

The C-14 labeled compound is mainly used as a tracer in educational researches and new drug development. Currently domestic companies, i.e. Curachem, Inc. and KRCC, Inc. are importing $Ba^{14}CO_3$, hich is made by irradiating neutrons on C-13 to meet the quantities they need. The recycling standard for C-14 as a labeled compound is commercial 50 mCi/mmol.

A porous alkaline earth adsorbent, suitable for the process in the spent resin disposal scenario, will be developed to test/verify the adsorption process with the most efficient porous BaO adsorbent.

Also, the C-14 adsorption efficiency of the developed adsorbent will be increased, and thus the import substitution of the labeled compound raw material can be expected.

5. Conclusion

For final disposal of the spent resin generated in the PHWR NPP, the treatment process and device were developed, and they were used to conduct verification experiments in Wolsong NPP #1.

The results of the verification experiments showed that more than 94.4% of the C-14 in the spent resin was desorbed, and the desorbed C-14 was adsorbed using the calcium-based adsorbent.

The authors are planning to enhance the technology for desorbing the C-14 in the spent resin, and use the barium-based adsorbent for the recycling of C-14 to improve the adsorption rate.

ACKNOWLEDGEMENT

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