

Design of Prototype (Part 1) that Treats Radioactive Waste Containing C-14

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1. Introduction

The domestic PHWR(Pressurized Heavy Water Reactor) nuclear power plant Wolsong Unit 1 was decided to be permanently stopped in December 2019. Accordingly, the need for permanent disposal of spent resin generated in PHWR nuclear power plant is emerging.

Currently, spent resin and activated carbon and zeolite are stored in a spent resin storage tank of a PHWR nuclear power plant.

In order to permanently disposal of the spent resin, it is necessary to secure separation and treatment technology from the mixtures.

Through a row research, "Development of the Spent Resin Treatment Technology Containing the C-14 for Disposal Safety Secure" a pilot scale treatment system with treatment capacity of 10 kg/8 hours was manufactured.

An empirical test was conducted on the spent resin mixtures collected from Wolsong Unit # 2 storage tank.

In this study, based on the results of prior research and development, a technical advancement and process design study was conducted to develop a spent resin mixtures separation automation facility (Part 1) of prototype of radioactive waste treatment facility containing C-14.

2. Method & Result

2.1 Development of Prototype (Part 1) of Radioactive Waste Treatment Facility Containing C-14

Prototype Part 1 of the radioactive waste treatment facility containing C-14 consists of three stages: the extraction process of the mixtures from the PHWR spent resin storage tank, the separation process of the drawn mixtures, and the quantitative transfer of separated spent resin.

In this study, the mixed resin (IRN-150), activated carbon, and zeolite, which are actually used in the phase of Wolsong Unit 1, were secured. A technical advancement study was conducted to improve the resin separation ratio corresponding to the spent resin mixtures separation process by applying a ratio of 8: 1: 1, the theoretical storage ratio of spent resin mixture.

The results were reflected in the prototype Part 1 design process of the radioactive waste treatment facility containing C-14.

2.2 Advancement of Separation Technology for Spent Resin Mixtures

Based on the problems and improvements from previous studies, a laboratory mixtures separation device was manufactured.

The laboratory separation device produced a vertical separation concept device developed in a previous study and a horizontal separation concept drum screen device used to remove fine suspended solids and impurities in a sewage treatment facility.

In the case of a vertical separation device, it was produced based on the concept of the separation device developed in the previous research.

In the case of the separation device produced in the previous study, it was manufactured with one separation screen in the separation tank.

The separation screen was made of mesh, and only spent resin was separated through the rotation of the impeller.

In the previous study, the applied [-] impeller served to mix the spent resin mixtures.

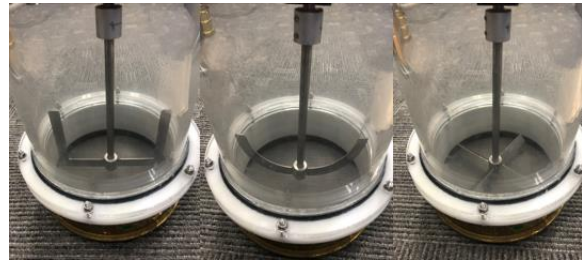


Figure 1. Impeller Shape [U], [X], [-]

In the aspect of technological advancement in this study, a separation efficiency experiment by each vortex generated according to the change of the shape and position of the impeller was conducted.

The impellers of [U], [X] and [-] shapes produced for the experiment are shown in Figure 1.

The vertical separation device was made of two separation screens, and the first separation screen was made of a punching plate with a size of 0.9 to separate a large amount of resin, a small amount of activated carbon, and zeolite microparticles.

By applying the first separation screen as a punching plate, the separation ratio of the resin was improved by effectively separating only the circular resin to be separated by reducing the separation surface area.

In addition, optimal separation conditions were derived by adjusting the shape / position and rotational speed of the impeller.

In the case of horizontal separators, the drum screen method was applied. Drum screens are mainly used in sewage treatment facilities and are used to remove fine suspended solids and impurities in wastewater.

Based on this method of separation, the drum screen was produced with a size 0.9 punching plate, and when the spent resin mixtures were injected into the drum screen, spent resin was separated into the lower part of the plate through rotation of the drum screen.

In addition, activated carbon and zeolite of the mixtures injected by the presence of blades in the drum screen are emitted by the rotation of the blades.

In addition, it is possible to adjust the angle of the drum screen and install a dispensing nozzle inside the drum screen to prevent the mixtures from rotating together on the wall of the drum screen.

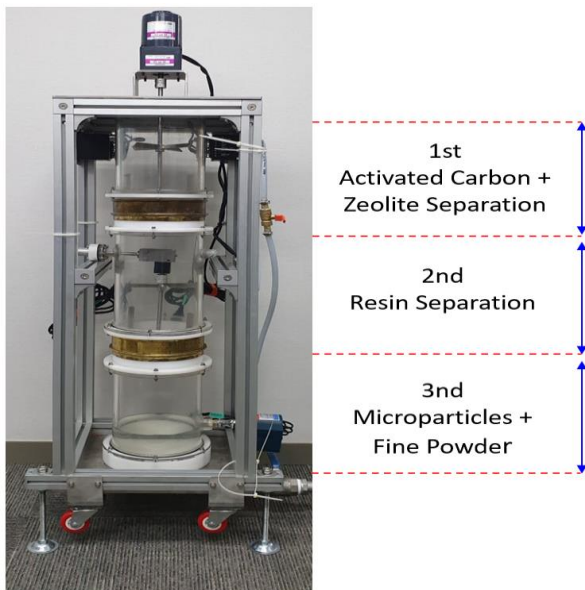


Figure 2. Vertical Separation Device

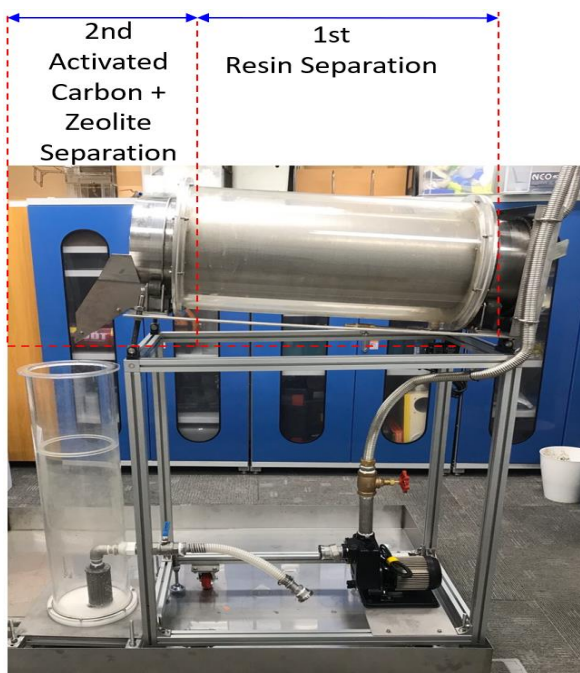


Figure 3. Horizontal Separation Device

Optimal separation conditions were derived through adjusting the angle and rotational speed of the drum screen.

2.3 Experiment Result

In the case of vertical separation devices, the impeller in the shape of [□] is located at the lower part and the optimum separation efficiency is derived when the impeller is rotated at a speed of 150 RPM.

The experimental results showed that the mock mixtures were separated for 2.5 kg/7 minutes and an average resin separation rate of 95% or more was obtained.

Currently, the daily throughput capacity based on the size of the vertical separator is approximately 250 kg/8 hours by applying the moisture content and is equivalent to 25% of the daily throughput capacity based on the prototype.

For horizontal devices, the angle of the drum screen was set to 3° and the optimum separation efficiency was reached when the drum screen was rotated at a speed of 3 RPM.

As a result of the experiment, the mock spent resin mixtures were carried out for 2 kg/7 minutes, and an average separation rate of 95% or more was obtained.

Currently, the daily throughput capacity based on the size of the horizontal separator is approximately 200 kg/8 hours by applying the moisture content and is equivalent to 20% of the daily throughput capacity based on the prototype.

Table 1. Resin Separation Ratio by Separation Device

Unit	Input (kg)	Moisture Content (%)	Corrected Input (A/kg)	Output (kg)	Moisture Content (%)	Corrected Output (B/kg)	Resin Separation Ratio (C=B/A×100%)
Vertical Separation Device	3.2	38	1.984	2.07	8.38	1.90	95.4
Horizontal Separation Device	2	37.66	1.25	1.71	30.35	1.19	95.2

In the case of the vertical separation device, the resin separation ratio was 95% or more.

However, the activated carbon and zeolite were crushed by the impeller when it was operated for more than the optimum separation time secured through lab test, resulting in additional fine particles.

In this experiment, the optimal separation time was derived by applying the theoretical storage ratio of the spent resin mixtures storage tank, but it is difficult to apply the optimal separation time obtained through the lab test because the ratio of the transferred spent resin mixtures is not constant when producing the prototype in the future and treatment the spent resin mixtures.

In addition, in the case of a vertical separation device, an additional process for removing activated carbon and zeolite as a batch type is required.

In the case of the horizontal separation device, the resin separation ratio was 95% or more. The horizontal

separation device is a method of separating through the rotation of the drum screen, rather than applying a physical force to the spent resin mixtures, and the amount of generating additional fine particles is very small.

In addition, in the case of the horizontal separation device, since resin separation, discharge of activated carbon and zeolite are simultaneously performed, no additional activated carbon and zeolite removal process is necessary.

2.4 Establish Process for Spent Resin Mixtures Separation Automation Facility (Part 1)

Advancement of the technology for separating wastewater mixtures developed through previous studies was conducted.

Based on the results, a process was established for the spent resin mixtures automation facility (Part 1) including the process of extracting spent resin mixtures from the PHWR spent resin storage tank, the process of separating the withdrawn spent resin mixtures, and the process of quantitative transfer of spent resin separated from the process.

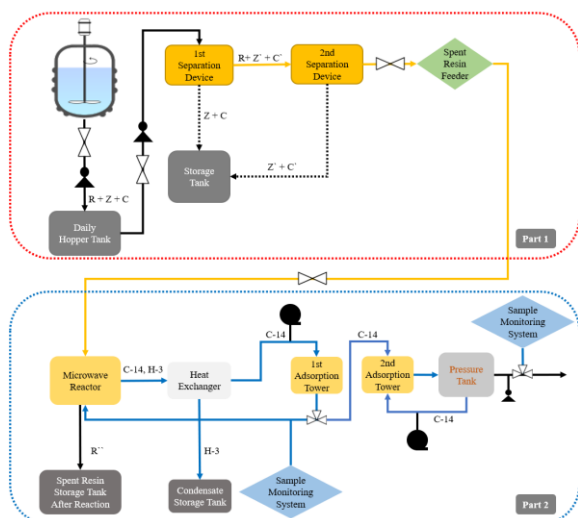


Figure 4. Design of Prototype that Treats Radioactive Waste Containing C-14

Through the analysis of Wolsong Unit 1 storage tank, Mock-up spent resin storage tank is manufactured and the site applicability evaluation is planned before the demonstration test of nuclear power plant in addition, the secondary separation tank is designed after separating the spent resin from the primary separation tank to consider the application of a method for removing fine particles and fine powder.

In the case of horizontal separators, problems derived from vertical separators were supplemented by separating them through the rotation of the drum screen.

However, the horizontal separation device also requires a small amount of activated carbon removal method having the same particle size as the resin.

In addition, the throughput capacity relative to the size of the horizontal separator is 200 kg/8 hours, which requires further verification to satisfy the daily target treatment capacity of 1 ton/8 hours, and is reflected in the production design of part 1 of the prototype of the radioactive waste disposal facility containing C-14.

3. Conclusion

In this study, the technology of separation of waste resin mixture obtained from prior research was advanced through the manufacture of vertical/horizontal separators.

In the case of the vertical separation device, a problem of generating additional fine particles by rotating the impeller and a method of removing a small amount of activated carbon having the same particle size as the resin are needed.

Acknowledgement

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