Development of Materials for Treatment of Radioactive Waste Generated from NPP using LLW and VLLW Soil/Concrete Waste

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1. Introduction

Radioactive waste is divided into HLW, ILW, LLW, VLLW and CW according to the radioactivity of wastes. KHNP expects that 80,794 drums of waste will be generated when Gori Unit 1 is decommissioned, of which 14,500 drums will be transferred to the disposal site[1].

Concrete waste is the largest amount of waste generated during the decommissioning of nuclear power plants, and most of them are self-disposable. However, there are 3,446 drums of concrete waste that must be transported to the disposal site. In addition, since a considerable amount of soil waste is expected to be generated during decommissioning, development of volume reduction technology to reduce disposal costs is required.

Most of the research related to the volume reduction of radioactive waste has been focused on the study of removing radionuclides from radioactive waste and reducing the radioactivity below the standard value for self-disposal[2]. However, since the volume reduction of waste using decontamination technology has technical limitations, alternative technologies are needed for additional waste volume reduction.

This study is being conducted to develop materials that can treat radioactive waste (gas, liquid and solid) generated from an NPP in operation or NPP being decommissioned using LLW and VLLW soil/concrete generated during decommissioning of NPPs.

2. Material Development Strategy for Radioactive Waste Treatment using Radioactive Waste

2.1 Separation of specific ingredients from waste

In order to manufacture materials to treat radioactive waste using soil and concrete waste generated from a decommissioning nuclear power plant, it is very important to separate the specific ingredients necessary for manufacturing the materials from the waste.

In general, soil waste contains a large amount of aluminosilicate, illite, zeolite, etc., so it can be used as a raw material for geopolymer through proper separation, extraction, and mixing processes. In addition, cement paste, excluding aggregates such as gravel and sand, contains a large amount of CaO, which can be used to manufacture alkali activator in the manufacturing of geopolymer, and can also be used as a raw material for Ca-based form filters. In this case, the technique of separating cement paste from concrete waste is very important.

On the other hand, since radioactive materials in soil are mostly present in fine particles of less than 0.075 mm and radioactive materials attached to large particles are known to be readily separable, additional reduction can be achieved if the soil is classified by particle size and radioactivity.

Fig. 1 shows the soil and concrete classification system according to the particle size used in this study. The crushed concrete and soil are fed into the hopper after a heat treatment process. Then, the soil and concrete are separated and discharged according to the particle size. The water used in the process can be reused after removing contaminants sequentially through a bag filter, submerged UF(Ultrafiltration) membrane, CDI(Capacitive Deionization), EDI(Electro-Deionization), etc.

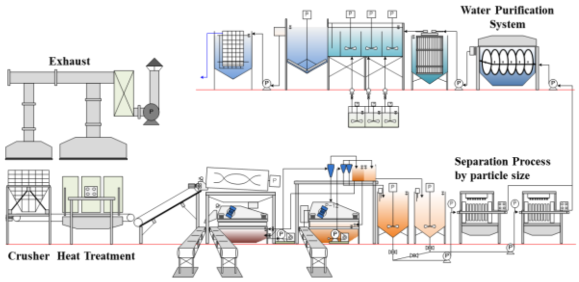
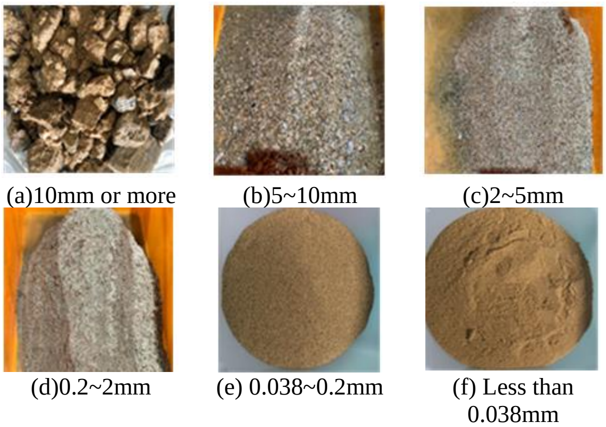


Fig. 1. Soil and concrete particle classification system.



(a)10mm or more (b)5~10mm (c)2~5mm

(d)0.2~2mm (e) 0.038~0.2mm (f) Less than 0.038mm

Fig. 2. soil classified by size in the pilot soil classification system.

Fig. 2 shows soil classified into six stages by particle size in a pilot-scale soil decontamination and classification system through previous research.

2.2 Materials for gaseous radioactive waste treatment

Gaseous radionuclides (I, Xe, etc.) generated in nuclear power plants are removed from the HVAC system composed of Pre-HEPA-Charcoal. In particular, the charcoal filter has 5% TEDA (Triethylenediamine) impregnated to remove radioactive iodine. In this study, CaO from concrete powder and SiO_2 from soil are the main ingredients and Al_2O_3 and MgO of steelworks are used as supplementary materials to design composition and develop porous ceramic form filters by liquid phase sintering. Fig. 3 shows a conceptual diagram of liquid phase sintering through a composition design and sintering aid using soil, concrete and steel waste generated from the decommissioning nuclear power plant and steelworks.

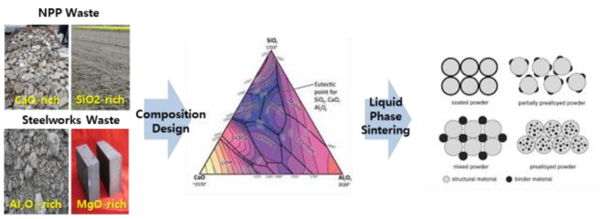


Fig. 3. Conceptional diagram of liquid phase sintering to manufacture hierarchy structure filter media using radioactive waste.

2.3 Geo-Polymer for Solidification of waste

Geopolymers are framework structures produced by condensation of tetrahedral aluminosilicate units and most of the core materials such as aluminosilicate, metakaolin, illite, zeolite, etc., which are raw materials, can be obtained from soil and concrete generated from decommissioning nuclear power plants. Also, it has excellent mechanical, physical and chemical properties compared to portland cement[3].

Geopolymer exhibits a wide variety of properties depending on the types of raw materials and alkali activators and their manufacturing conditions. Metakaolin and fly ash containing large amounts of reactive amorphous silicon and aluminum are commonly used in the synthesis of geopolymers. Alkali activators include alkaline aqueous solutions such as NaOH, KOH, and $Ca(OH)_2$ in silicate solutions and $Ca(OH)_2$ can be obtained from concrete waste from decommissioning nuclear power plants. In addition, geopolymer has different characteristics depending on the Si/Al mole ratio or Na/Al mole ratio, etc., so the mixing ratio must be considered.

In this study, kaolinite obtained from soil waste generated from decommissioning NPP is heated at temperatures of 550 to 600℃, converted to metakaolin, and used as a raw material for geopolymers. In addition, $Ca(OH)_2$ extracted using hydrochloric acid from concrete waste from decommissioning NPP is intended to be used as an alkali activator when manufacturing geopolymers.

The developed geopolymer can be used for solidification of radioactive sludge, radioactive concentrated liquid, and metal waste generated in nuclear power plants.

3. Conclusions

Volume reduction technology of radioactive waste generated from decommissioning nuclear power plants is a necessary technology for direct reduction in disposal costs. This study is to develop a material that treats radioactive waste using radioactive waste as a raw material, and is approaching with a different paradigm from the traditional volume reduction technology by decontamination.

Performance evaluation will be conducted using simulated and actual radioactive wastes so that materials developed by this study can be applied to gas, liquid, and solid radioactive waste generated from the currently operating NPP. All assessment items shall be implemented in accordance with the test specifications and standards applied to nuclear power plants, and the conformity of the relevant regulations for the radioactive waste acceptance is also evaluated.

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