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Technical note

Volume reduction of radioactive combustible waste with Oxygen Enriched Incinerator

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A B S T R A C T

The aim of the paper is to describe the current status of management for the decommissioning of combustible waste in KAERI. In Korea, two decommissioning projects have been carried out due to the retiring of nuclear research facilities, i.e., the Korean research reactors (KRR-1 & KRR-2) and a uranium conversion plant (UCP). The decommissioning of KRR-2 and the uranium conversion plant (UCP) at KAERI were completely finished by 2011, whereas the decommissioning of KRR-1 is currently underway. For the purpose of a volume reduction of the combustible waste generated from the decommissioning projects, incineration technology has been selected for the treatment of combustible waste. About 16.4 tons of combustible waste has been treating using Oxygen Enriched Incineration. The temperature; pressure of the major components; stack gas concentrations, i.e., SO_x, NO_x, CO, CO_2 and HCl; and residual oxygen were measured. The major parameters measured during normal operation were sustained at a stable status within criteria of the operation condition. Oxygen enriched air, 22 vol.% (dry basis) was used for stable incineration. The volume reduction ratio achieved was about 1/65.

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1. Introduction

Decontamination and decommissioning (D&D) becomes one of the most important nuclear industries in developed countries. In Korea, two decommissioning projects have been carried out owing to the retiring of nuclear research facilities (KRR-1 & KRR-2) and a uranium conversion plant (UCP). The decommissioning of the KRR-2 and a uranium conversion plant (UCP) at KAERI were completely finished by 2011, whereas the decommissioning of KRR-1 is currently underway. A large quantity of radioactive waste was generated during the decommissioning of the KRR and UCF. Table 1 shows the amount of decommissioning waste generated from the decommissioning project.

Among the total 2200 tons of waste from the decommissioning of the TRIGA MARK II, such as concrete, soil, combustible and non combustible waste. The more than 200 tons of radioactive metal waste was generated. In the case of UCP radioactive metal waste, approximately 200 tons was generated during the decommissioning project (Min et al., 2012). Incineration technology is an effective treatment method that contains hazardous chemicals as well as radioactive contamination (Brunner and Dee, 2012). An incinerator burns waste at high temperature. Incineration of a mixture of chemically hazardous and radioactive materials, known as "mixed waste," has two principal goals: to reduce the volume and total chemical toxicity of the waste. Incineration itself does not destroy the metals or reduce the radioactivity of the waste. The main purpose of incineration radioactive waste is to reduce the waste volume, since a large proportion consists of bulky items such as contaminated paper, cloth, gloves, shoes, lumber, and plastic.

The purpose of this paper is the volume reduction of decommissioning combustible wastes generated by the decommissioning projects.

2. Facility run

2.1. Facility description

An incineration facility was built to demonstrate the applicability for hazardous and low-level radioactive waste treatment from a nuclear facility. Fig. 1 shows a process diagram of Oxygen-Enriched Incineration (OEI). The system consists of a waste preparation system, an incineration system, an off-gas cooling system, and an off-gas treatment system. The oil incinerator, gas exchanger, and ion exchanger equipment were closed during normal operation because the decommissioning waste did not include oil or high chlorine content waste. The Incineration facility was constructed in 1997.

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Table 1
Decommissioning burnable waste of KRR and UCP.

Classify	KRR		UCP	
	Radioactive waste	Releasable waste	Radioactive waste	Releasable waste
Burnable waste (tons)	10.7	32.3	310.0	3.7

The operation license of the incineration facility was authorized by KINS in August 2011. The incineration facility has been in operation since that time. An incinerator and afterburner are included in the incineration system. The incinerator was designed to have a single cylindrical chamber, a waste feeding unit, several combustion air inlets, and an ash collect box. The inside diameter is 50 cm and the height is 122 cm. The size of the incinerator is estimated using a mass balance equation with a proper residence time and a hydrodynamic consideration of the combustion to have a capacity of 25 kg. An incinerator has a sub burner for preheating and a main burner for incineration. Combustion air is blown down into the incinerator through many small holes tangentially arranged. Gases leaving the incinerator pass and enter the afterburner where air and fuel are added to increase the gas temperature to 900 °C.

The purpose of the afterburner is to complete the combustion process that began in the incinerator, complete the combustion of any CO, and destroy VOCs in the off-gas leaving the incinerator. The off-gas cooling system is composed of a heat exchanger and air diluter. The off-gas cooling system is divided into two sections, hot and cold. The heat exchanger cools the gas from the afterburner rapidly to about 400 °C by contacting the atmospheric temperature. Before the air diluter equipment, the temperature in the lines is above 400 °C. In addition, the off-gas cooled down to less than 200 °C when using the diluter for proper operation of the cold filtering units. The air diluter is a mixer of hot flue gas and cold ambient air. The exhaust gas is rapidly cooled to approximately 200 °C. The incineration building is equipped with a HVAC system, which was designed to provide ventilation capacity for the incineration facility operation. The primary area of the ventilation is the incineration room, which is the major source of heat and radioactivity. The secondary area of the system's auxiliary facility room, which has the possibility to be contaminated with radioactivity, generates a small amount of heat. The decommissioning combustible waste consists of lumber, paper, cotton, cloth, gloves, vinyl, and PVC. The decommissioning radioactive combustible waste was packaged in about a 0.7 kg/package and put into a paper bag to be fed easily into the incineration chamber through the sliding double gate at the upper position of the incinerator.

2.2. Material

The main materials of incineration radioactive waste consist of contaminated lumber, paper, cotton, cloth, gloves, vinyl, and PVC. A summary of the incineration material is shown in Table 2. All instruments for indicating the status of each point of the process such as pressure, temperature, and flow rate were already turned on. The wastes are processed through the upper position of the incinerator using two sliding gates. The combustible waste was packed using a paper bag. The weight of the single packages of lumber, cotton, vinyl, PVC, and mixed waste were around 1.5 kg. After incinerating the radioactive waste, bottom and fly ash collected at bottom of incinerator, afterburner and bagfilter which was used to estimate the volume and weight reduction ratio. Decommissioning combustible wastes were composed of various types such as lumber, wood, paper, cotton, cloth, glove, vinyl and PVC. Therefore, it is difficult to gaining an accurate volume reduction radio using wastes density. Actually decommission combustible waste was packaged in 200 L drum. Volume reduction ratio defined as volume of total wastes put into incinerator/volume of ash after incineration.

2.3. Operation condition and off-gas analysis

Table 3 shows a measured major operation parameter during a normal operation of the incineration. When the combustion chamber is preheated to 450 °C using the oxygen burner, the oxygen and paper waste packages are fed into the chamber, and oxygen combustion is started. Decommissioning combustible waste packages are fed in continuously until the combustion temperature reached above 800 °C. The thermal destruction of most organic compounds occurs between 590 °C and 650 °C. Once the combustion temperature teaches a desired temperature, the waste is fed in at every

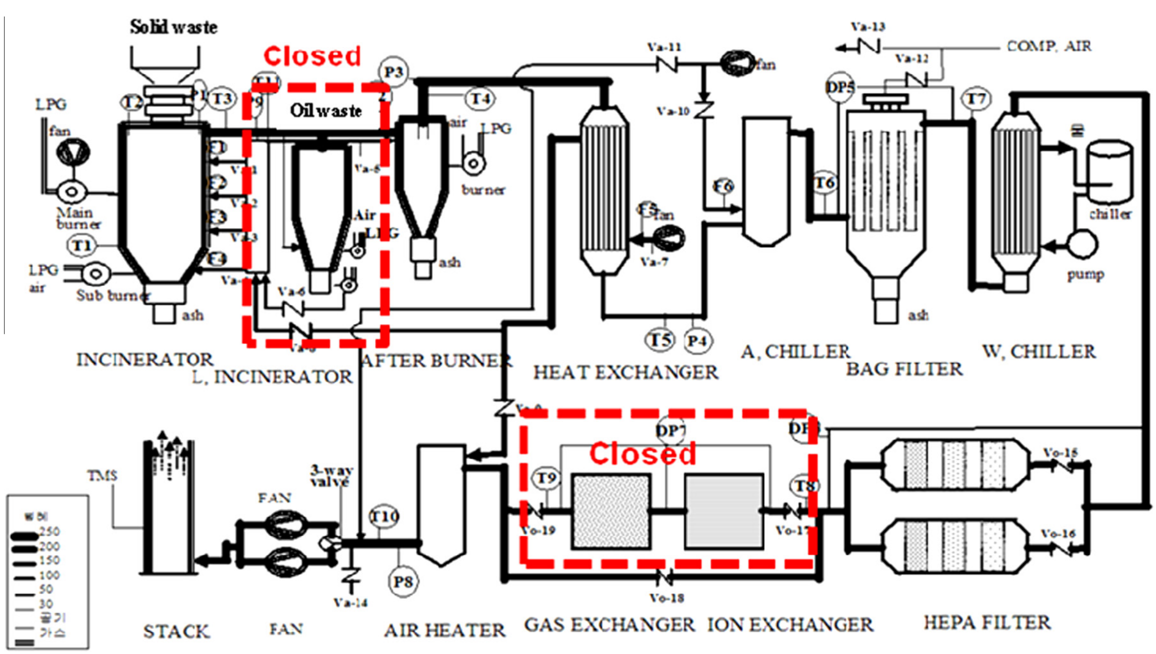

Fig. 1. A schematic diagram of Oxygen-Enriched Incineration system.

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