Study on Utilization of Materials arising from Decommissioning Research Reactors

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Abstract

We calculated hydrogen production rate by simulating a stacked layer module with the material of which radiation level is one order higher than the upper limit of low-level L2 class as a case study. The calculation showed that the hydrogen producing rate get to $2.53*10^4 m^3$/year when using the total amount of intermediate L1 class waste arising from decommissioning research reactors. Considering the situation where disposal plan of the radioactive waste is unclear, it will be useful to consider the research and development aimed at minimization of radioactive waste by using equivalent to L1 class material as valuables as we studied.

1. Introduction

Research and development for peaceful uses of nuclear energy began 1950s in Japan, and 29 research reactors have been constructed to date. Among them 13 units are under decommissioning and 9 units are already completed their decommissioning so far. When decommissioning of large facilities such as the JMTR goes into full swing, a large amount of radioactive waste will be generated. However, to date there is no facilities for disposing of the waste. It should be an important issue to consider proper handling of this waste. In this study, we reviewed open materials for characterizing the radioactive waste arising from decommissioning research facilities. Then discussed the possibility of waste reduction effort such that hydrogen production rate by γ-rays emitted from L1-equivalent material was calculated in a case study. Possibility of waste minimization is discussed in the study.

2. Methodology

We reviewed decommissioning implementation policies published by universities and research institutes in Japan and summarized the status of the facilities in decommissioning with estimating the amount of radioactive waste arising from decommissioning. In addition, hydrogen production rate was calculated using Monte Carlo calculation code (phits) as a case study by simulating stacked layer module with radiation source (Co-60), scintillator, water, and photocatalyst (Fig.1). The hydrogen production rate (M_0 mol/s/g) can be obtained using the formula $M_W = E * W * B * x * y * z * 0.5 / 6.02 * 10^{23}$, of which parameters E, B, x, y, z mean γ-ray energy (MeV), radioactivity of source material (Bq/g), scintillator light emission efficiency (photons/MeV) and hydrogen production yield of photocatalyst, where E, B, z and y are set as 1.25, $1.0 * 10^{16}$, 17,000, 0.96, respectively [2), 3)].

3. Results and Discussion

(1) Characteristic of radioactive waste arising from decommissioning : The total amount of radioactive waste arising from decommissioning of all existing research reactors (excluding power reactors) is found to be about 23,000 tons where those are classified by radiation levels as intermediate level L1:308 tons, low level L2 :3,656 tons, and very low level L3:19,294 tons. Figure 2 shows the comparison of the radioactive waste volume among planned facility capacity, total in estimated, arising from JAEA facilities and arising from decommissioning. The amount of L1 waste is not large accounting for less than 2% of the total in decommissioning research facilities. However, the problem is how handling the L1 waste since there is no disposal plan.

(2) Hydrogen production rate : Under Fig.1 system, γ-ray efficiency for scintillator luminescence was calculated to be 0.33 resulting in $4.21 * 10^{-9} m^3/s$ of hydrogen production rate in the stacked layer module system (at room temperature). The hydrogen production rate and γ-ray efficiency in each module is shown in Fig.3. When assuming the operation of the system for one year, the hydrogen production rate will be $0.52 m^3$/year. When using the total amount of L1 waste (308 tons) the hydrogen producing rate get to be $2.53*10^4 m^3$/year. Applying a hydrogen price (at hydrogen stations) of 2,000 yen/kg, the cost per $1.0 m^3$ is approximately 180 yen/nm^3, indicating that annual hydrogen production is equivalent to about 4.55 million yen/year.

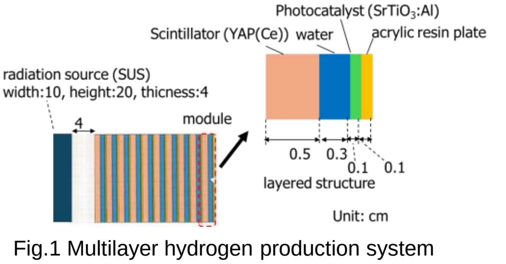

Fig.1 Multilayer hydrogen production system

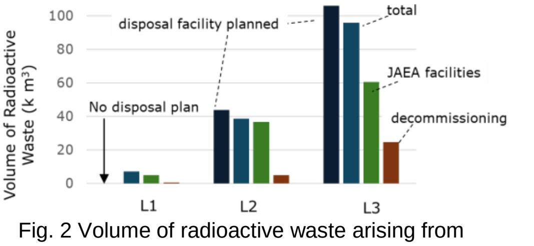

Fig. 2 Volume of radioactive waste arising from operation and decommissioning of research facilities

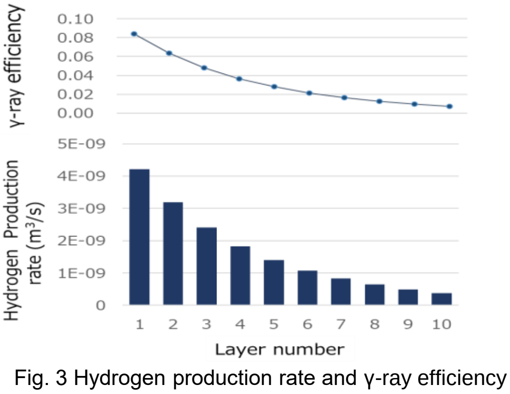

Fig. 3 Hydrogen production rate and γ-ray efficiency in each module

4. Summary

- Since there are 13 research facilities under decommissioning so far, it is a significant issue to properly handle the large amount of radioactive waste which is categorized to L1:308 tons, L2:3,656 tons and L3:19,294 tons.
- Hydrogen production rate was calculated by simulating a stacked layer module system with the material categorized to L1 as a case study. It was found that the hydrogen production rate get to $0.52 m^3$/year equivalent to approximately 4 million yen annually for 308 tons of L1 material.
- Under the current situation of that the disposal facility is not clearly identified, it will be useful to consider the research and development aimed at minimization of radioactive waste by using equivalent to L1 class material as valuables as we studied. It should contribute to the creation of both recycling society and a hydrogen society.

Reference

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