Techniques for Section Gamma Scanning of PWR Spent Nuclear Fuel

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1. Introduction

The section-gamma scanning aims to measure a distribution of fission products through the radial scanning of a fuel section. This technique is used for the determination of a radial burnup in PIEF, KAERI. Also the gamma scanning data on a spent fuel provides important information for the improvement of the design and the process condition of the nuclear fuel with metallography results. The analysis on the gamma spectroscopy requires a process of massive data and has some subtle difficulties. Therefore the specialists of the gamma-spectroscopy should cooperate closely with specialists of the nuclear fuel.

The fuel samples was sectioned in 3mm thickness, mounted and polished. The hot mounting was used for the fuel sample injected with the epoxy resin. The section gamma scanning was performed using 0.5mm × 0.5mm slit through the radial direction of a fuel sample. The gamma spectrum obtained by the gamma scanning shows the radial distribution, the isometric projection and contour plots of a radioactive nuclide.

2. Sampling and analysis methods

The sample preparation is very important in the two-dimensional gamma scanning. The most ideal sample is thought to be thin, but in case of the oxide fuel it is difficult to make a thin sample without a loss of fuel fragments. The appropriate fuel thickness was determined in 3mm as follows.

- Proper radioactivity enough to measure the gamma peak of a nuclide.
- More thicker, more signal strength. But also the thick fuel sample takes more gamma scattering influence.
- Proper to handle samples by manipulators.
- Easy to maintain uniform thickness in sampling.

After mounting and polishing, a fuel sample was put on the sample holder of the section gamma scanning bench by manipulators in order to seek a reference coordinate, moving the sample table in X or Y direction. Also a distance between a sample and a detector (40.5 cm), between a collimator and a sample (2 cm), a slit size (0.5 mm × 0.5 mm), nuclides that will be analyzed, dwelling time were determined and then a gross gamma scanning was performed on a fuel sample automatically.

The gamma spectra of nuclides were determined using a high-resolution Ge detector, EGPC-20, a high density collimator and a multi-channel analyzer (MCA), CANBERRA series-90. The spectra were analyzed using the MCA which can determine area and centroid of a gamma peak of each gamma emitting fission products. And a computer code, Isotope Library was used to confirm a radioactive nuclide which correspond to a gamma peak by using standard gamma sources; Cs-137 (662 keV), Ce-144 (2,186 keV).

3. Results

The fuel samples with nominal enrichment of 4.2% of 235U and decay time of 1.5 years were taken from a fuel rod of the Yong-Gwang Unit-1 power plant. Figure 1 shows a spectrum in the result of gamma spectroscopy on a fuel sample. Relatively long half-life nuclides were detected such as Ru-106, Cs-134, Cs-137, Ce-144 and Eu-154. Count rates of Cs-137 and Cs-134 were higher than the others. In comparison with count rate of Cs-134, Cs-137 (662 keV) was shown to be about 80%, Eu-154 (1274 keV) about 5% and Ce-144 (2,186 keV) about 7%. If radioactive nuclides have sufficient and stable count rate, it is considered that it is possible to assess Pu content, neutron spectrum and decay time.[1~4] For the micro-gamma scanning, the highest gamma emitting nuclide, Cs-137 was selected because production rate of this nuclide from U-235 is similar with that from Pu-239 and count rate of Cs-137 has low statistical error and is in proportion to burnup. But cesium was reported to migrate even below 800°C in case of 41 GWd/tU burnup. Figure 2 shows the isometric projection of Cs-137 on a spent fuel sample taken from a domestic commercial fuel rod. This exhibits the maximum value in an outer region of the pellet and a lower value in center than the others.[5]

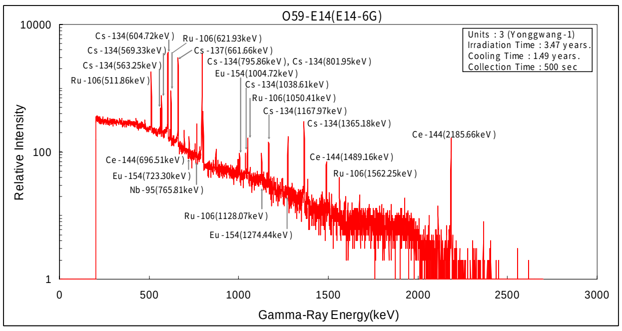

Fig. 1. Gamma-ray Spectrum of Spent Nuclear Fuel.

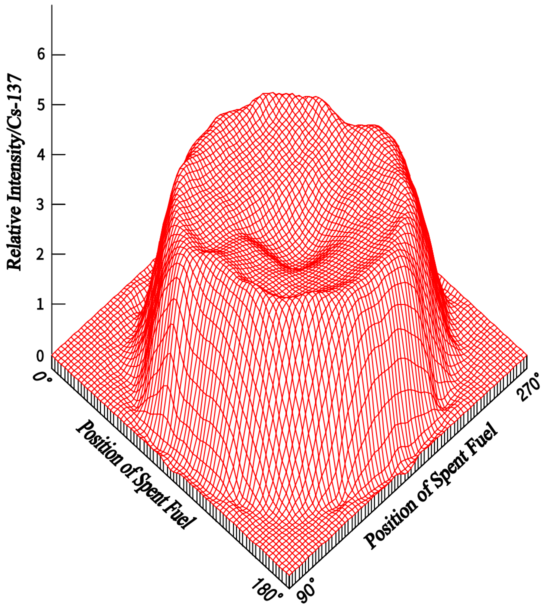

Fig. 2. Isometric Projection of Cs-137 Isotopic Radial Distribution.

4. Conclusion

Micro-gamma scanning is being performed in PIEF, KAERI to measure gamma spectrum of the fuel rod, distinguish nuclides and analysis a burnup profile. This information hints the migration of a nuclide and the condition of a fuel pellet. The continuous and careful gamma spectroscopy on the fuel in hot-cell should be performed in order to obtain good quality information of the spent fuel.

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