Spent Fuel Burnup Measurement Test by SICOM NG-FA Inspection System

Yongdeog Kim[a]*, Kiyong Kim[a], Donghee Lee[a], Hyungkoo Kim[b], Sehyun Oh[c]
[a]*Central Research Institute, KHNP, 70 Yusong-daero 1312, 34101*
[b]*KEPCO Nuclear Fuel, 242 Daeduk-daero, 34057*
[c]*Users Co., Ltd., #530, 65 Techno-ro 3, 34016*
[*]*Corresponding author: yongdkim@khnp.co.kr*

1. Introduction

The nuclear properties of spent fuel are determined by the initial fuel composition, burnup experienced in a nuclear reactor, cooling time, and etc. The radioactivity assessment of the spent fuel assembly can be performed from initial enrichment, burnup, and cooling time of the fuel assembly. The average burnup value of each spent fuel assembly is especially determined at the time of discharge from the reactor core operation history and the distribution of in-core neutron flux measurement during operation. IAEA has specified data requirements of records for spent fuel management and the average burnup of the spent fuel is one of the key data to be managed [1]. A burnup verification measurement has been contributed to get a burnup credit by providing nuclear criticality safety in US and European countries [2]. The application of burnup credit can result in more efficient way to load spent fuel assemblies in a storage or transportation cask, therefore, it can significantly reduce cost and risk.

This study has been performed to investigate an applicable burnup verification measurement by comparing the measurement data with the reactor record data of the spent fuel assemblies. The commercially used radiological characterization system, SICOM NG-FA, that can measure gamma-ray and neutron counts under water at room temperature has been used in this study (Fig.1).

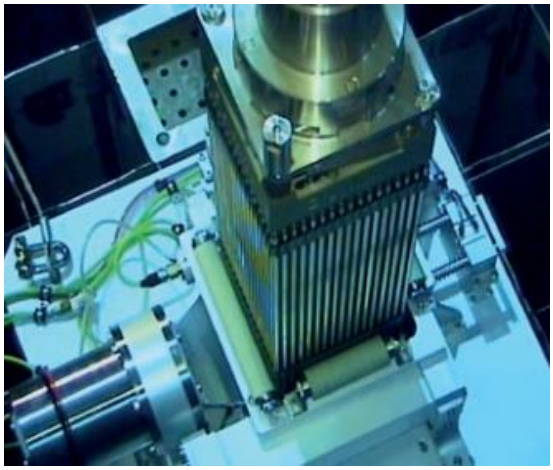

Fig. 1. SICOM NG-FA Inspection System [3]

2. Verification Measurements

2.1 Spent Fuel Selection

Twenty spent fuel assemblies were selected for the burnup verification measurement study. The initial enrichment of the assemblies ranged from 2.9 to 4.65 wt.% U-235. The range in average assembly burnup was from 25.9 to 54.1 GWd/MTU and the cooling times ranged from 4 to 21 years. The various kinds of fuel types were selected such as KSFA, PLUS7, GUARDIAN that have 16×16 array in a fuel assembly.

2.2 Burnup Measurement Test

The burnup measurement test was performed at the spent fuel pool storage side in nuclear power plant. During the burnup measurement test, both the SICOM NG-FA system and test fuel assembly were placed on the empty cell position among the region 1 of spent fuel pool to minimize background radiation from neighboring spent fuel. The gamma-ray and neutron flux counts were measured along the axial position of four faces of each spent fuel assembly. Measurement was performed while moving the spent nuclear fuel up and down.

3. Results and Discussion

Measured burnup value was determined associated with the gamma and neutron emission rates with analytical models by TRITON, ORIGAMI, and CSAS5 simulations. The activity ratio, i.e. count rate ratio, as a function of burnup was obtained by ORIGEN calculations. Fig. 3 shows typical neutron spectrums from the four faces of a spent fuel. It didn't show significant difference in neutron counts value between the faces of the spent fuel assembly. The average Cs-137 count rate as a function of the fuel assembly axial height was shown in Fig. 4.

The overall measured burnup error will be presented with the reactor record data based on in-core neutron flux measurement. It is expected that the burnup measurement system could fulfill an important role as a means of burnup verification method.

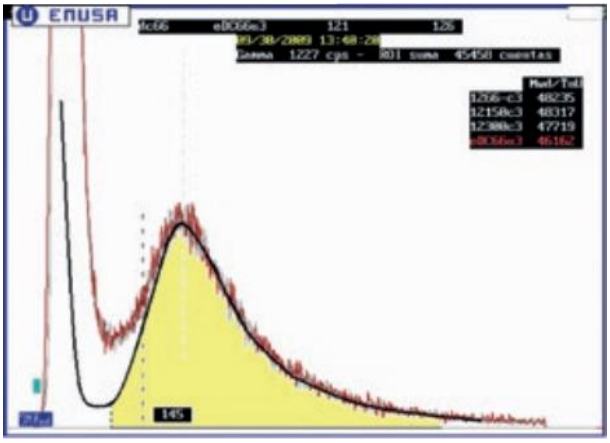

Fig. 3. Typical neutron spectrums from four faces of a spent fuel assembly

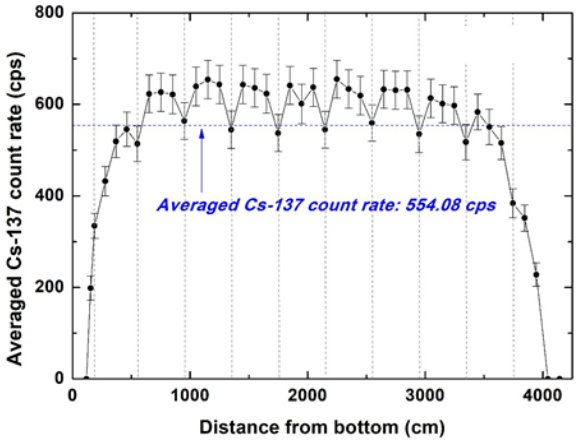

Fig. 4. Measured Cs-137 gamma-ray spectrums distribution as a function of fuel assembly height

4. Conclusions

The burnup measurement study on the spent fuel has been performed to investigate an applicable burnup verification measurement by comparing the measurement data with the reactor record data of the spent fuel assemblies based on in-core neutron flux measurement. The overall measured burnup showed a good agreement with the reactor record. It is expected that the SICOM NG-FA burnup measurement system can be utilized as a means of burnup estimation method in the future.

REFERENCES

[1] IAEA TECDOC-1519, “Data Requirements and Maintenance of Records for Spent Fuel Management”, 2006
[2] EPRI TR-113169, “The Fork+ Developmental Measurement Campaign at Maine Yankee”, 1999
[3] ENUSA/TECHNATOM, “Nuclear Fuel Inspection (https://www.enusa.es/wp- content/uploads/)”, 2016