Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 7-8, 2015

Current Status of Burnup Evaluation for Test Fuel at HANARO

Seong Woo Yang*, Seung Jae Park, Yoon Taeg Shin, Kee Nam Choo, Man Soon Cho
Neutron Application Technology Division, Korea Atomic Energy Research Institute, Yuseong-gu, Daejeon, 305-353
Corresponding author: swyang@kaeri.re.kr

1. Introduction

Recently, the demand of in-pile test for the nuclear fuel using HANARO irradiation facility is increasing.

For the light water reactor, the irradiation test capsule containing both dual cooled fuel and high performance fuel was irradiated[1]. Also, micro cell UO_2 pellet for enhancement of accident tolerant ability and boron bearing UO_2 pellet for replacement of rare earth element will be irradiated.

For the GEN-IV nuclear system, U-Zr and U-Zr-Ce metallic fuels were irradiated for sodium-cooled fast reactor (SFR)[2]. 2nd irradiation test for SFR fuel is planned, so the conceptual design of irradiation test capsule is conducting. The in-pile test of coated particle fuel for very high temperature gas cooled reactor (VHTR) was also conducted[3].

For the research reactor, 8 mini plate fuels were irradiation-tested during 4 irradiation cycles. 2 more irradiation capsules were fabricated for additional test of plate type fuel[4]. Also fission Mo target for the performance verification and the demonstration of Mo-99 extraction process will be irradiated at HANARO.

It is important to evaluate the burnup history of test fuel. The burnup of test fuel has been calculated using HANARO Fuel Management System (HANAFMS)[5]. Although it is proper to evaluate the burnup of HANARO fuel, it is difficult to accurately calculate the burnup of test fuel due to the limitation of HANAFMS model. Therefore, the improvement of burnup evaluation for the recent irradiated test fuel is conducted and reported in this paper.

2. Results and Discussions

2.1 Burnup calculation using HANAFMS

The irradiation test of HAMP-1, the first batch of HANARO Mini Plate irradiation test, was conducted for 108.41 effective full power days. Since the calculation model of HANAFMS is composed of H-Z, it is hard to evaluate the burnup of each plate. Fig. 1 shows the horizontal model of HANAFMS for HAMP-1. To calculate the burnup, the hexagonal lattices of first and second ring were homogenized. Therefore, the average burnup of 4 plates are calculated from HANAFMS. Therefore, only 2 axial sections were considered for HAMP-1.

Fig. 2 shows the burnup calculation result for HAMP-1 by HANAFMS. The final burnups of lower and upper part are 132.4 and 105.7 GWD/MTU, respectively.

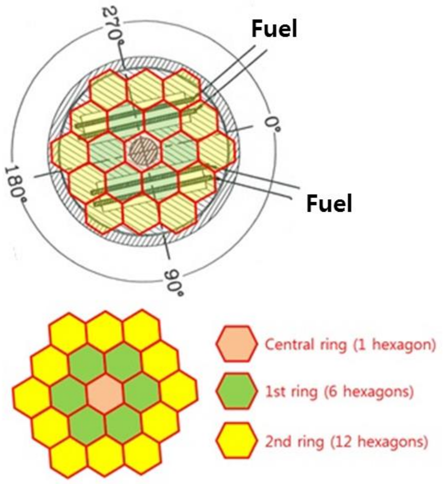

Fig. 1. The horizontal model of HANAFMS for HAMP-1

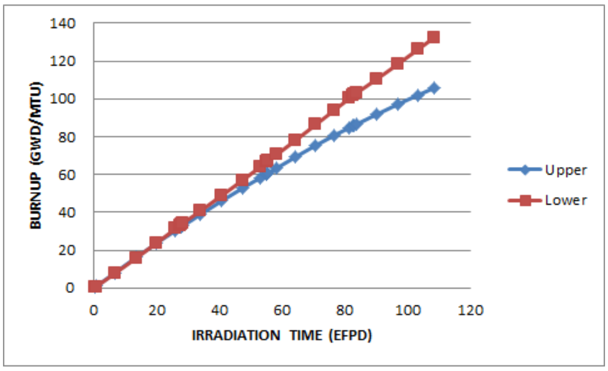

Fig. 2. Burnup calculation result for HAMP-1 by HANAFMS

2.2 MCNP model with burned HANARO fuel

MCNP is widely used to calculate the reaction rate, flux and spectrum in the research reactor due to its the flexibility of geometry. To construct the MCNP burned core model, the calculation flow shown in fig. 3 was used. Representative compositions of specific HANARO fuel burnup groups are calculated throughout HANARO core depletion by MCNP6. The burnup information of 13,104 HANARO fuel sections, 14 axial sections in 1 rod, from HANAFMS is used for MCNP cell/material input. The calculation frequency of MCNP burned core model was same with HANAFMS, 28 calculations in the case of HAMP-1. After the kcode calculation, HANARO fuel assembly power and criticality were compared.

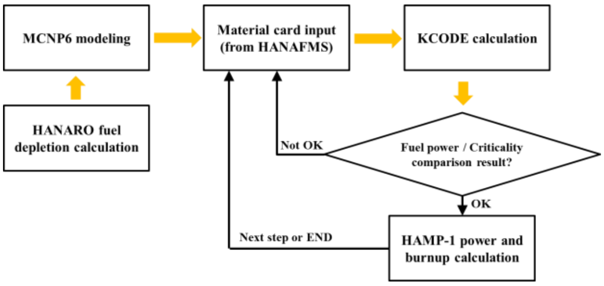

Fig. 3. Calculation flow of MCNP burned core model

Fig. 4 shows the root mean square error (RMSE) of HANARO fuel assembly power between HANAFMS and MCNP burned core model. The RMSEs were less than 3% in all 48 calculation results from 89 to 95 operation cycle of HANARO. Therefore, MCNP burned core model is also reliable due to the good agreement with the HANAFMS.

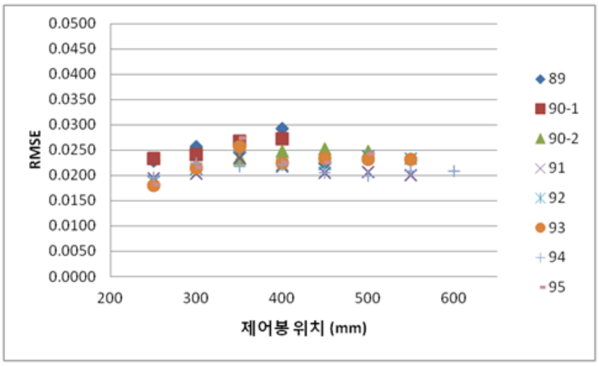

Fig. 4. Root mean square error of HANARO fuel assembly power between HANAFMS and MCNP burned core model

2.3 Burnup evaluation of test fuel using MCNP

To evaluate the burnup for each plate of HAMP-1, MCNP burned core model was used. Fig. 5 shows each plate average burnup of HAMP-1. The calculation result was less than the result of HANAFMS.

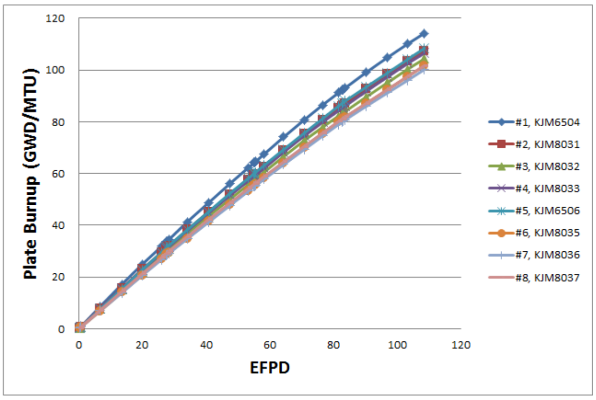

Fig. 5. Burnup calculation result of HAMP-1 using MCNP burned core model

3. Conclusions

To evaluate the burnup of test fuel, HANAFMS has been used; however, HANAFMS model is not proper to apply plate type fuel. Therefore, MCNP burned core model was developed for HAMP-1 burnup calculation. Throughout the comparison of fuel assembly power, MCNP burned core model showed the good agreement with HANAFMS.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation (NRF) of Korea grant funded by the Korea government (MSIP). (NRF-2013M2A8A1035822)

REFERENCES

[1] D. H. Kim et al., The Irradiation Test Plan of the Multi Purposed Hybrid Fuel in HANARO, KAERI/TR-4370/2011.
[2] J. S. Cheon et al., Safety Analysis Report for the 1st Irradiation Test of SFR Metallic Fuel, SFR-FD330-WR-02-2010 Rev.00.
[3] B. G. Kim et al., Irradiation Test Plan of Coated Particle Fuel at HANARO, KAERI/TR-4875/2013.
[4] Y. W. Tahk et al., Test Plan for Mini-Plate Irradiation with U-7Mo Dispersion Fuel in HANARO, KJ-374-KN-442-012.
[5] C. S. Lee et al., Analysis of Reactor Characteristics for Equilibrium core of HANARO, KAERI/TR-2320/2002.