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Comparisons of Fission Rate Distributions with Experimental Data

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1. Introduction

The BFS-75-1 experimental program was carried out and the comparison between calculation and experiment was performed[1]. In case of BFS-75-1 critical experiment core, there exists a strong heterogeneity because the core is composed of a lot of plate type pellet to simulate the reactor core instead of fuel pins used in the actual core. The core design is commonly performed based on the homogeneous model and differences with the actual core calculations scheme happen, so that the heterogeneity corrections are needed to correct these differences.

In this paper, the calculation results on the fission reaction rate distribution which shows a large heterogeneity effect are analyzed. To analyze the heterogeneity of the fission reaction distribution, homogeneous and heterogeneous model calculations were performed.

2. Analysis Method

2.1 BFS-75-1 Critical Assembly Description

The BFS-75-1 critical assembly was constructed at the BFS-1 facility in 1998 for investigating basic neutronics characteristics of a simple, two-zone configuration with a typical neutron spectrum in a uranium metal fueled fast reactor. The core has a simple and homogeneous configuration fueled with LEZ(Low Enrichment Zone) of 15.11% enrichment as inner core and HEZ(High Enrichment Zone) of 19.96% enrichment as outer core.

The LEZ, as shown in Figure 1, consists of 91 fuel elements. The HEZ consists of 162 fuel elements. The fuel elements in the LEZ region and the HEZ region were composed by 8 unit cells and 2 axial blanket unit cells. The unit cell of the fuel element in the LEZ region was composed by 1 uranium metal pellet of 90% enrichment, 2 uranium metal pellets of 36% enrichment, 4 ^{238}U metal pellets, 5 sodium pellets and 2 zirconium pellets. The unit cell of the fuel element in the HEZ region was composed by 2 uranium metal pellets of 90% enrichment, 1 uranium metal pellet of 36% enrichment, 4 ^{238}U metal pellets, 5 sodium pellets and 2 zirconium pellets.

2.2 Nuclear Design and Analysis Methodology

The microscopic cross sections were generated by utilizing the effective cross section generation module composed of the TRANSX[2] and TWODANT[3] codes. To get the flux distribution inside a unit cell, the TWODANT code was used after the generation of 80 group effective cross section through cell calculation of the LEZ region and the HEX region. Flux calculations were carried out with the DIF3D code.

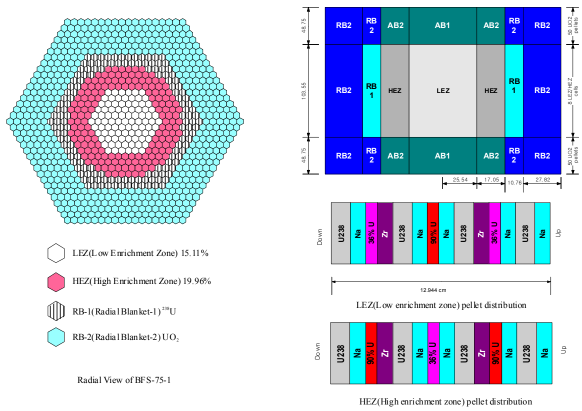
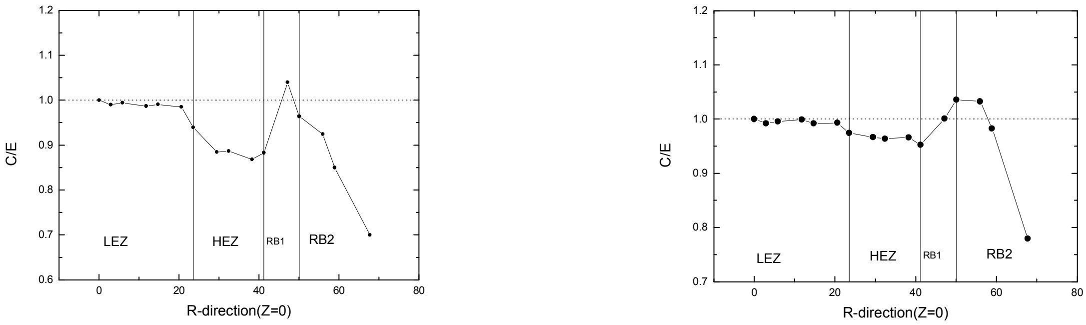


Figure 1. Layout of BFS-75-1 Critical Assembly

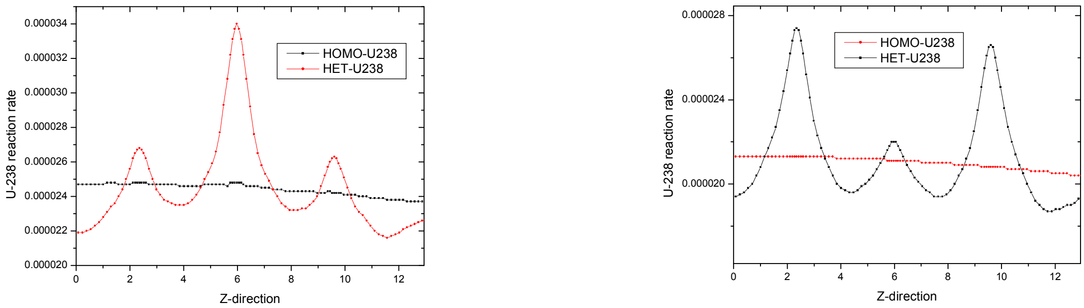
3. Analysis Result

The calculated ^{238}U and ^{235}U fission rate distributions in the radial direction are compared with measured data in Figures 2. It shows that the calculated ^{238}U fission rate distributions underpredict within 2% in the LEZ and 12% in the HEZ on the average. In case of ^{235}U fission rate distribution, discrepancies appeared to be within 1 % in the LEZ and 4 % in the HEZ on the average, respectively. From these comparisons, it is commonly observed that C/Es in the HEZ show the more deviation than those in the LEZ, especially in the ^{238}U fission rate distributions. The reason that the calculated values largely underestimated the radial fission rate of ^{238}U seems to be stemmed from the plate heterogeneity effect in the axial direction. As seen in the right bottom of Figure 1, the core region is composed of many stacked plate type pellets. When the fission reaction rate measurements were performed, normally the detector was located in the middle plane in the axial direction. In case of measurements in the HEZ region, the detector was encountered by uranium pellet with high enrichment instead of low enrichment. As that result, the relative measured fission rate in the HEZ region might show a higher value than the one in the LEZ region. But during calculations all compositions of fuel pellets were homogenized in this analysis so the calculated value would show a lower value than the measured one in the entire core region, especially the large deviation of C/Es in the HEZ. Figure 3 shows this tendency of the relative high reaction rates in the HEZ region compared with the results of the homogeneous models.



(a) ^{238}U Fission Rate (b) ^{235}U Fission Rate

Figure 2. Comparisons of Calculated (C) and Experimental (E) Radial Fission Rate Distributions



(a) ^{238}U Fission Rate(LEZ) (b) ^{238}U Fission Rate(HEZ)

Figure 3. Radial Fission Rate Distributions inside Unit Cell

4. Conclusion

The previous validation calculation showed a lot of C/E discrepancies for fission rate distribution. To investigate these discrepancies, the detailed fission reaction rate distributions inside cell were calculated. The heterogeneous models could describe the complex fission reaction rate distribution inside a unit cell, while the homogeneous models could not. It shows that the heterogeneous model calculations are important to predict fission rate distributions in a highly heterogeneous configuration.

Acknowledgments

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