3.1 Experimental Study on Uranium-Free Fast Reactor at FCA

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Fast reactors have a potential to flexibly cope with the demand and supply of plutonium because of their good neutron economy. Recently, fast reactors for burning plutonium, instead of breeding, have been actively studied[1,2]. For plutonium burning, fast reactors using highly enriched plutonium or uranium-free fuel are considered preferable to enhance the fission reaction of plutonium and to reduce the capture reaction of uranium. In order to experimentally validate the calculation accuracy for such plutonium burning fast reactors, a unique core without uranium was constructed at the FCA assembly XIX-3B, and sample reactivity worth of plutonium and B_4C and sodium void reactivity worth were measured.

The core consisted of a test region (49 cm in diameter and 61 cm in length), a driver region and a blanket region. All the measurements were performed in the test region that consisted of plutonium, sodium and stainless steel. In Table 3.1.1, atomic number densities of the test region are compared with those of a reference MOX core, XVII-1[3], which simulated the prototype LMFBR core. The XIX-3B core contained twice of plutonium and steel in comparison with the XVII-1 core, while neither uranium nor oxygen was included in XIX-3B. The resultant normal and adjoint neutron spectra in the test region are compared with those of the XVII-1 core in Fig. 3.1.1. It is clearly observed that the neutron spectrum of XIX-3B core shifts to high energy and that the adjoint neutron spectrum decreases with neutron energy between 20 and 500 keV where that of the XVII-1 core shows opposite slope.

The measured items were the axial distribution of plutonium sample worth, the B_4C sample worth for various ^{10}B enrichments, and the axial distribution of sodium void reactivity worth.

As for the calculation, the 70-group library, JFS-3-J3.2, based on JENDL-3.2 was used. For the cell calculation , the SLAROM code was used. The reactivity worth was calculated by the 70-group diffusion approximation in an RZ-geometry. The transport correction was performed for the non-leakage term and the leakage term separately in the calculation of the sodium void reactivity worth.

The measured and the calculated sample worths are compared in Fig. 3.1.2 and Fig. 3.1.3 for plutonium and B_4C, respectively. A very good agreement was observed for both plutonium and B_4C sample worths. This implies that the axial flux distribution and neutron spectrum were well calculated by the present cross section library and calculation method.

On the other hand, the measured and the calculated sodium void reactivity worths are compared in Fig. 3.1.4, where the calculated values are decomposed into the non-leakage and leakage terms. It should be noted that the sodium void reactivity worth shows a negative value even at the core center, since the adjoint neutron spectrum decreases with the neutron energy below 500 keV as shown in Fig. 3.1.1. The calculation underestimates the absolute value of the sodium void reactivity worth by about 30 % at the core center, whereas this underestimation tends to be reduced at the core axial edge. This tendency suggests that the non-leakage term, which is dominant at the core center, is underestimated and the leakage term, which increases with the distance from the core center, is fairly well predicted. Further study on the non-leakage term is, therefore, necessary to explain this underestimation.

References

1) Languille, A., et al. : "CAPRA core studies − The Oxide Reference Option", Proc. Int. Conf. Evaluation of Emerging Nuclear Fuel Cycle Systems, GLOBAL '95, Versailles, France, September 11-14, 1995, Vol. I, p. 874 (1995).
2) Wakabayashi, T., et al. : Nucl. Technol., 118, 14 (1997).
3) Oigawa, H. and Iijima, S. : J. Nucl. Sci. Technol., 35, 264 (1998).

Table 3.1.1 Atomic number densities (10^{22}atoms/cm^3)

Nuclide	Core name XIX-3B U-free fast reactor	Core name XVII-1 Prototype LMFBR
^{239}Pu	0.21	0.11
^{238}U	------	0.69
O	------	1.70
Na	0.96	0.77
Fe	2.67	1.22

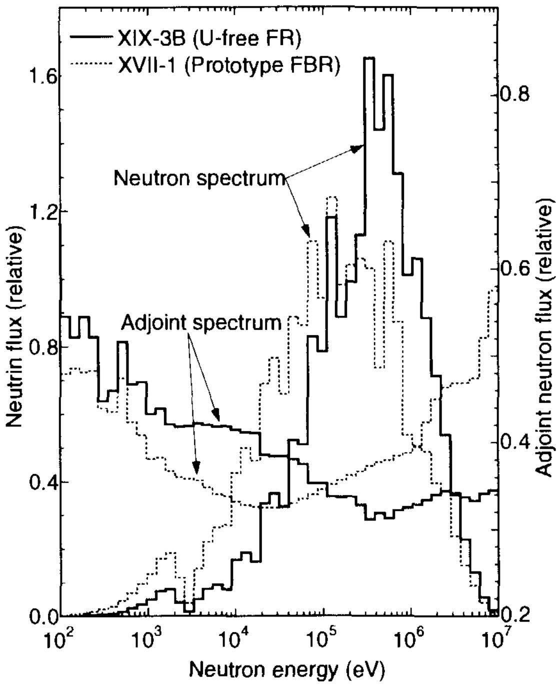

Fig. 3.1.1 Normal and adjoint neutron spectra in the test regions of FCA cores

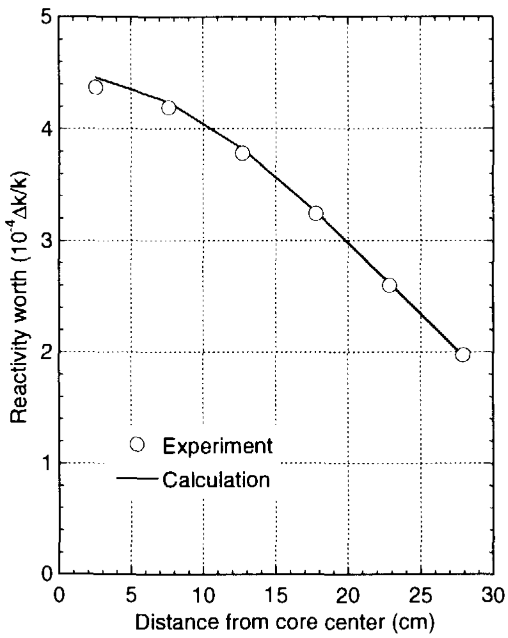

Fig.3.1.2 Results of plutonium sample worth

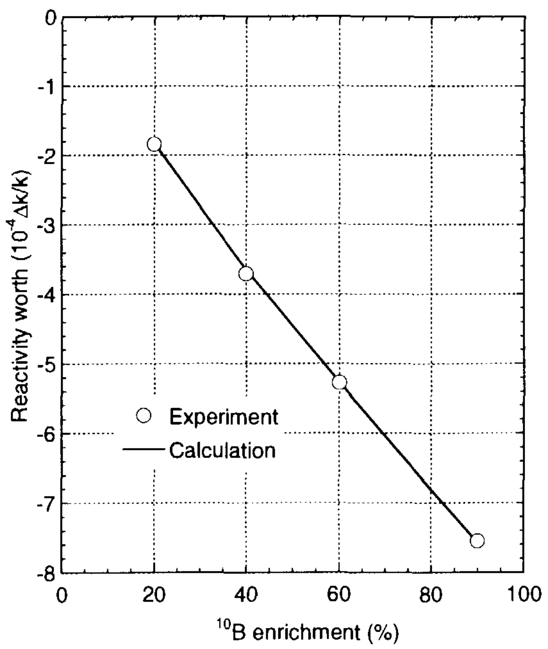

Fig. 3.1.3 Results of B_4C sample worth

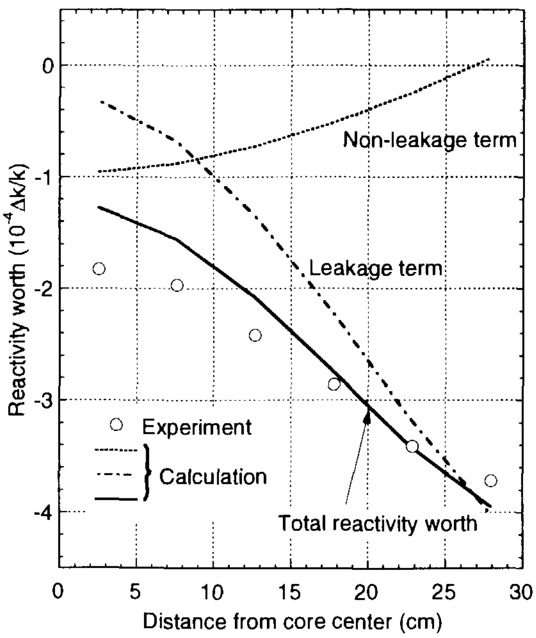

Fig. 3.1.4 Results of sodium void reactivity worth