3.3 Measurement of GEM Reactivity Worth at FCA

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The Gas Expansion Module (GEM) was designed[1] to add negative feedback to sodium cooled fast reactors in case of a loss-of-flow accident. Reactivity worth of the GEM external to the core (Ex-core GEM) had been measured using a small FBR mockup core (XIX-2G core) at Fast Critical Assembly (FCA) to estimate calculation accuracy for the GEM reactivity worth.[2] In this study, Ex-core GEM reactivity worth was measured in a FBR mockup core (FCA XX-1 core) using sodium blocks which newly prepared to simulate GEM.

Experiment

The XX-1 core is a large size FBR mockup core constructed at the FCA (the volume of the core region is 883 ℓ). The core region consists of a mixed nitride (MN) fuel region and MOX and enriched uranium (EU) driver regions. The core region is surrounded by a soft blanket (SB) and depleted uranium blanket (DUB) regions. The Ex-core GEMs are located in the SB region adjacent to the EU-driver in horizontally symmetric positions. The horizontal cross section of the core is shown in Fig. 3.3.1(a).

The GEM is simulated by the use of the sodium blocks covered with stainless steel. GEM reactivity worths were measured as the reactivity change caused by replacing the sodium blocks with empty cans. The sodium blocks were replaced step by step (-20.3cm, -66.0cm, -111.8cm and -132.1cm from the top of the GEM) to simulate the decrease of the sodium level in the GEM. To investigate dependence of the calculation accuracy on the volume of the voided area, sodium voided area in the GEM was varied as follows: 6cm×17cm, 11cm×17cm and 17cm×17cm (see Fig. 3.3.1(b)). Measured GEM reactivity worths are shown in Fig. 3.3.2.

Analysis

The experiment was analyzed using the standard analysis method[3] for FBR cores at FCA and the JFS-3-J3.2 group constant set generated from the JENDL-3.2 library[4]. A set of 70-group constants for the GEM was calculated using the Tone's method[5] considering the effect of the neighboring core region. The GEM reactivity worth was calculated by the exact perturbation theory with 25-group energy structure in XYZ geometry. The transport effect was considered for leakage and non-leakage term separately in R-Z geometry.

The result of the calculation is shown in Table 3.3.1. The leakage term is dominant for all the cases; a ratio of the non-leakage to leakage term is -0.06. It is pointed out from Table 3.3.1 that the transport effect on the leakage term is significant. The C/E values are

also shown in Table 3.3.1. The calculations overestimated the experiments more than 10%. It was found that there was no significant dependence of C/E values on the sodium level, while the degree of the overestimation increased with enlarging voided area.

References

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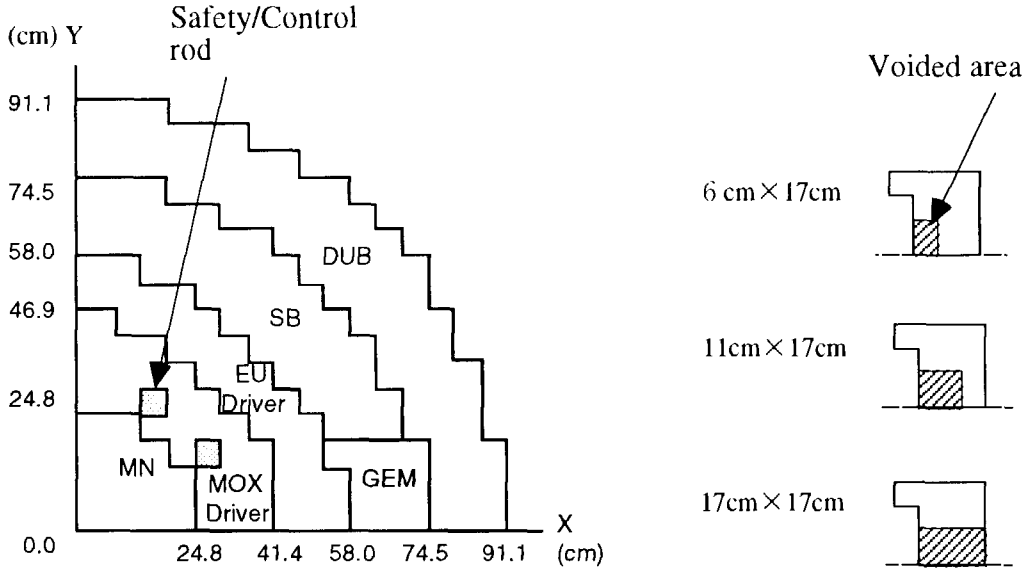
2) Oigawa, H., et al. : "Measurement of External GEM Reactivity Worth at FCA", JAERI-Review 98-022, p. 78(1998).
3) Iijima, S. : private communication.
4) Nakagawa, T., et al. : J. Nucl. Sci. and Technol., 32, 1259 (1995).
5) Tone, T. : "A Numerical Study of Heterogeneity Effects in Fast Reactor Critical Assemblies", J. Nucl. Sci. and Technol., 12(8), 467(1975).

Table 3.3.1 Result of the analysis on the GEM reactivity worth

Void area & sodium level (cm)	Transport effect NL[a)]	Transport effect L[b)]	Calcualted GEM reactivity worth ($\times 10^{-4}\Delta k/k$)	C/E
6cm×17cm				
-20.3	1.07	0.494	-0.51	1.12±3.7%[c)]
-66.0	0.887	0.683	-5.03	1.07±0.6%
11cm×17cm				
-20.3	1.10	0.582	-0.97	1.16±2.0%
-66.0	0.897	0.722	-9.26	1.12±0.5%
-111.8	0.878	0.765	-17.2	1.12±0.5%
-132.1	0.897	0.736	-18.3	1.12±0.5%
17cm×17cm				
-20.3	1.12	0.608	-1.27	1.28±1.7%
-66.0	0.926	0.738	-12.2	1.16±0.5%
-111.8	0.905	0.782	-22.6	1.16±0.5%
-132.1	0.929	0.754	-24.0	1.17±0.5%

a) Non-leakage term, b) Leakage term, c) Experimental error



(a) XX-1 core　　(b) Voided area in the GEM

Fig. 3.3.1 Horizontal cross section of the XX-1 core and voided area

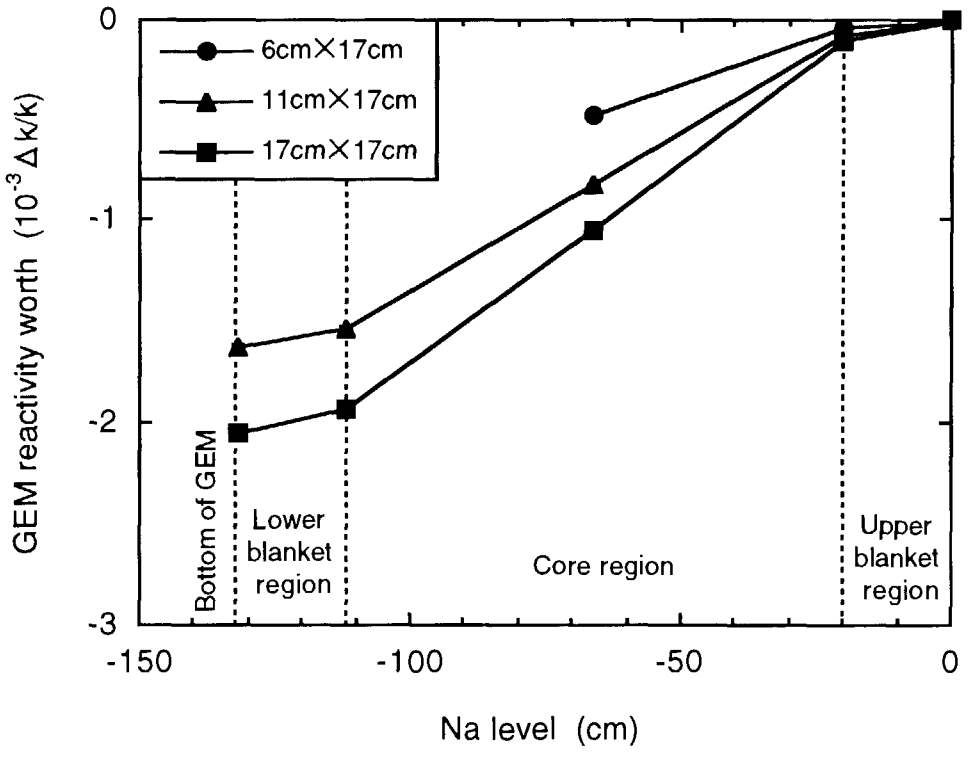


Fig. 3.3.2 Experimental results of the Ex-core GEM reactivity worth