Computation Method Comparison for Th Based Seed-Blanket Cores

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Introduction

One of the possible approaches to introduce thorium into the LWR fuel cycle is by the use of the so called Whole-Assembly Seed Blanket design (WASB) [1]. Replacing a standard (U) fuel by the thorium based fuel is justified by the following design objectives:

1. Significant reduction, or if possible, elimination, of the fuel cycle proliferation potential.
2. Reduction of the spent fuel storage/disposal volume and of safety requirements.
3. A potential increase in natural uranium utilization and a consequent decrease in fuel cycle cost.

Seed and blanket designs can be analyzed using various whole core neutronic simulation tools. However, in some of the simulation tools, for example the Studsvik Core Management System (2-D code CASMO [2] and 3-D code SIMULATE [3]), a 2-D transport code can generate the burnup dependent cross-sections for the Seed and Blanket fuel regions only by performing separate transport calculations, one for each, without accounting for the mutual spectral effects of the heterogeneous region. The objective of this study is to investigate the importance of these effects.

Description of the work

This work compares two methods for calculating a given nuclear fuel cycle in the WASB configuration. Both methods use the ELCOS Code System (2-D transport code BOXER and 3-D nodal code SILWER) [4] are compared.

In the first method, the cross-sections of the Seed and Blanket, needed for the 3-D nodal code are generated separately for each region by the 2-D transport code.

In the second method, the cross-sections of the Seed and Blanket, needed for the 3-D nodal code are generated from Seed-Blanket Colorsets (Fig.1) calculated by the 2-D transport code.

The evaluation of the error introduced by the first method is the main objective of the present study.

Results

Seed and blanket region assemblies with white boundary conditions were calculated with the 2-D transport code Boxer by the two methods described above. The difference in the reactivity of the seed and the blanket, between the two methods, is shown in Fig.2 and Fig.3. The maximum difference obtained from the 2-D code is: up to 0.7 percent in seed and up to 4 percent in blanket.

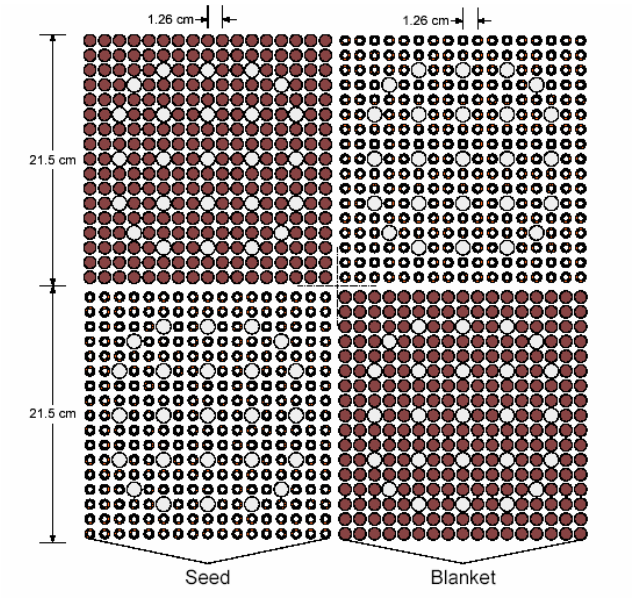

Fig 1 – The Seed-Blanket colorset

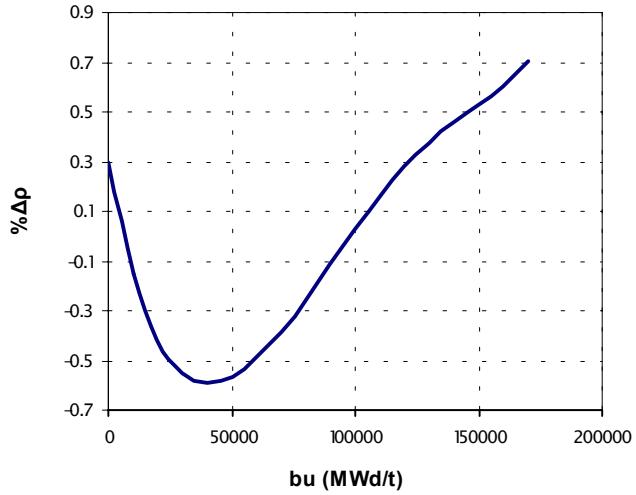

Fig. 2. The difference in the reactivity of seed between the two methods

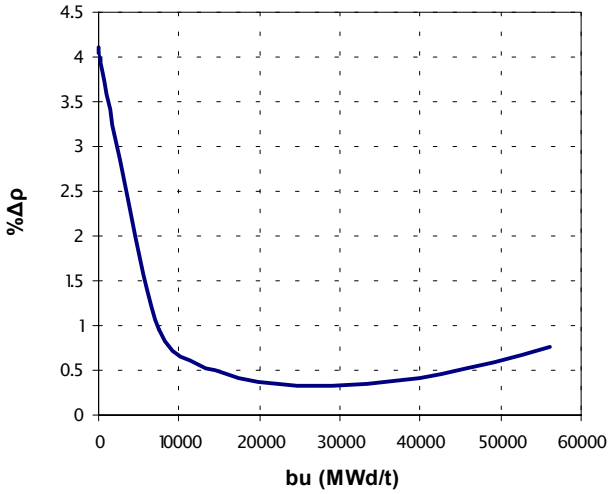

Fig. 3. The difference in the reactivity of blanket between the two methods

The seed and blanket regions burnup dependent cross-sections that were generated by the 2-D code, with the two methods, were used as input database for the 3-D nodal code SILWER. Identical core configurations were examined with the cross-sections prepared with the two

methods and the difference in the reactivity between the two calculations is shown in Fig.4. The maximum difference in the reactivity between the two methods does not exceed 0.22 percent.

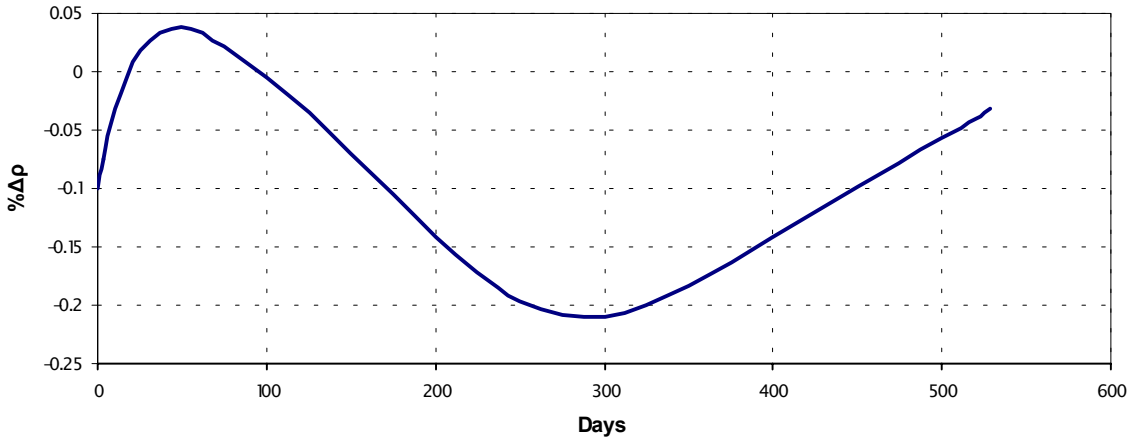

Fig. 4. The difference in the core reactivity vs. days (The lengths of the cycle 530 days) between the two calculations

Conclusions

A heterogeneous Seed-Blanket design, of typical WASB dimensions, may be evaluated with sufficient precision without colorsets calculation, namely with cross-sections generated separately for region with a 2-D transport code. The importance of inter-region spectral is small (less then 0.25 percent of Δρ) and therefore can be neglected.

References:

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[4] Paratte J.M., Foskolos K., Grimm P., Maeder C., "The PSI code system ELCOS for stationary calculation of light-water reactors", Proc. Jahrestagung Kerntechnik, Travemuende, Germany, P.59, May 17-19, (1988).