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Performance Evaluation of CMFD with Superhistory method on Continuous Energy Monte Carlo Eigenvalue Simulation

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1. Introduction

The Coarse Mesh Finite Difference Method (CMFD) has been widely used to accelerate the convergence of deterministic methods [1-8]. It was shown that the CMFD acceleration technique is very effective for fission source convergence. It was expected that CMFD is also effective on active cycle by reducing inter-cycle correlation. However it turns out CMFD also has inter-cycle correlation. In order to reduce the inter-cycle correlation, well known technique superhistory method was adopted [9-11]. In this paper, the tally performance of CMFD with superhistory method was studied with 1D homogeneous problem.

2. Algorithm

Fig. 1 shows the algorithm of CMFD with superhistory method. There are two additional things comparing standard Monte Carlo (MC). CMFD with superhistory method uses multiple generations in one cycle. After each cycle, the CMFD calculation was performed and the fission source distribution was adjusted.

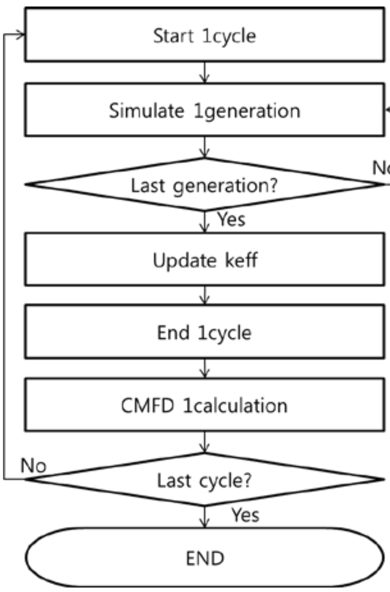

Fig. 1 Algorithm of CMFD with superhistory method.

3. Numerical Test

3.1 Problem Specification

Fig. 2 shows the geometry of 1D test problem. The size of the problem is 260 cm and it filled with homogeneous material of fuel and coolant.

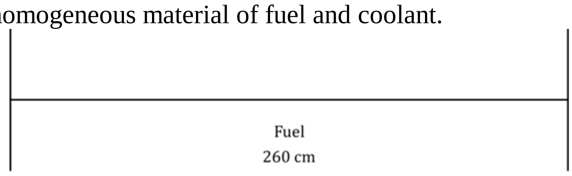

Fig. 2. Geometry of 1D problem.

3.2 Sensitivity Test of Superhistory Method

The sensitivity test depending on the number of superhistory generation was performed. There are 6 test cases: 3 for superhistory method and 3 for superhistory with CMFD. Every cases use same number of histories per cycle. The number of histories per generation is determined with the number of generations per cycle. Each cases use 100 inactive, 1,000 active cycle, and 200,000 histories per cycle. Three numbers of generations were tested: 10, 250, and 1,000 generations per cycle. Fig. 3 shows the RMS real STD depending on the number of superhistory generations. With low number of histories, the magnitude of RMS real error increase as superhistory generations increase. And the RMS real STD slope is getting closer to the ideal shape. The ideal slope can be achieved with 1,000 generations. It also can be achieved with 250 generations if the CMFD is used at the same time.

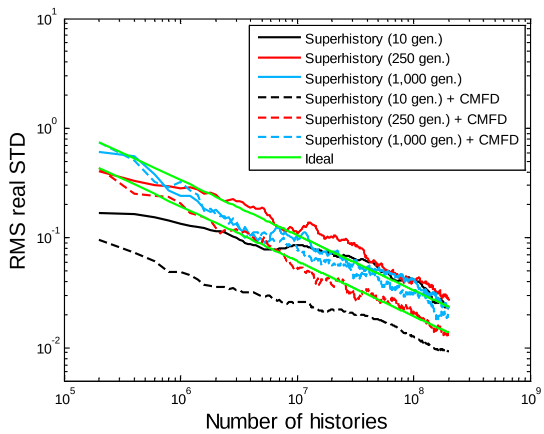

Fig. 3. RMS real STD depending on the number of superhistory generations.

3.3 Comparison with Other Methods

As shown in the Fig. 3, the 250 superhistory generations with CMFD shows best result. The slope is ideal and the magnitude of RMS real STD was lower than that with 1,000 superhistory generations. In this chapter, four cases were compared: Standard MC, MC with CMFD, MC with superhistory method, and MC with CMFD and superhistory method. Fig. 4 shows the RMS real STD of flux. As shown in the graph, Standard MC, CMFD, and superhistory method do not follow ideal slop which is 1/sqrt(n). On the other hands, MC with CMFD and superhistory follow the ideal shape.

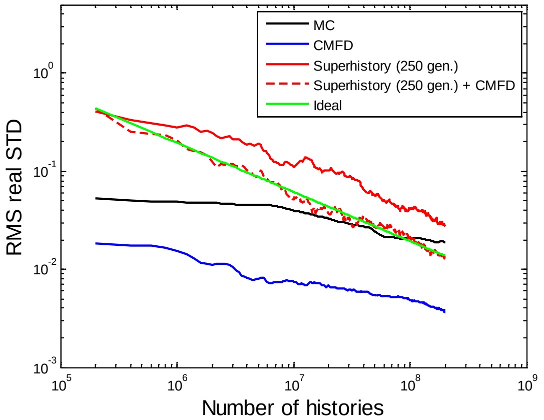

Fig. 4. RMS STD Vs. number of histories.

The fission source was tallied with mesh size of 130 cm. The autocorrelation coefficient was calculated using fission source as Eqs. (1-2).

$$ACCs(k) = \frac{\sum_{i=1}^{N-k}\left(X_i - \bar{X}\right)\left(X_{i+k} - \bar{X}\right)}{\sum_{i=1}^{N}\left(X_i - \bar{X}\right)^2}, \quad (1)$$

where

$$X_i = \frac{s_{i,2}}{s_{i,1} + s_{i,2}},$$

$\bar{X}$ is the average of X_i for every cycle, $s_{i,1}$ is the fission source of left region at cycle *i*, and $s_{i,2}$ is the fission source of right region at cycle *i*. Fig. 5 shows the autocorrelation coefficient.

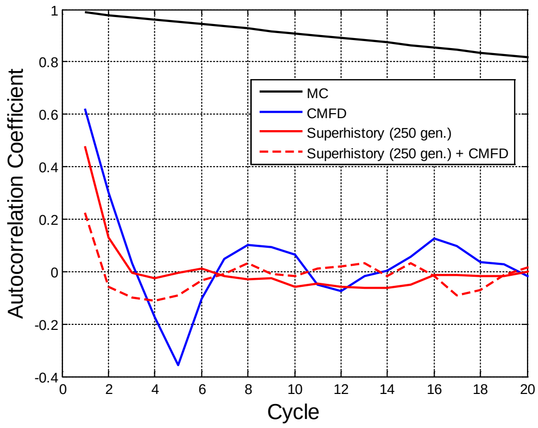

Fig. 5. Autocorrelation coefficient.

3. Conclusions

The effect of CMFD with superhistory method on the MC was studied. It was shown that the inter-cycle correlation was reduced dramatically with CMFD and superhistory method. The magnitude of RMS real STD increases as the number of generations for superhistory increases. And the magnitude decreases with CMFD. Therefore, it was possible to get ideal shape with smaller RMS STD with CMFD and superhistory.

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