Comments on "The Effects of Intracell Adjoint Flux Heterogeneity on First-Order Perturbation Reactivity Calculations"

I find Smith's[1] paper on the effects of intracell adjoint flux heterogeneity on reactivity calculations interesting and a contribution to the understanding of the long-standing issue of the central worth discrepancy (CWD) in fast critical assemblies. The effects of intracell adjoint flux heterogeneity on small samples' reactivity worth (and, therefore, also on the CWD) were examined in the past using different approaches from that used in Ref. 1. The purpose of this Letter is to remind the Journal readers of several of the approaches used in the earlier studies.

Integral transport theory methods (based on the collision probability formulation) were developed in the late sixties and early seventies to calculate the adjoint (as well as forward) flux and reactivity worth in fast critical assemblies, taking into account the heterogeneous structure of these assemblies. An example of such methods is described in Ref. 2. This method, embodied in the KAPER computer code, indeed reduced the CWD (as compared with the CWD obtained for a homogeneous core model). For reasons not clear to me, the development and use of these integral transport theory (i.e., high-order) perturbation methods have been confined, to a large extent, to Europe.

There are a number of first-order perturbation theory methods other than that used by Smith[1] to account for the intracell adjoint flux distribution on the calculated reactivity worth. One of these methods—that using bilinear flux weighting—is mentioned by the author (p. 455 of Ref. 1). Another method is the consistent flux (CF) method. In the CF method, all the heterogeneity effects are accounted for in the calculation of the homogenized group cross sections. It uses an effective perturbation operator, which accounts for both the physical perturbation and for spatial and spectral fine-structure effects due to the heterogeneous geometry. Details about, and references for the application of the CF and the consistent bilinear (CB) methods for reactivity worth calculations can be found in Ref. 3.

Whereas the method used by Smith[1] can correct for spatial fine-structure effects starting at the group structure level, the CB and CF methods can, in principle, account for spatial as well as spectral and angular fine-structure effect, starting from the energy-dependent cross-section description.

Finally, the reader might be interested to know that the effect of heterogeneity on the (spatial and spectral) adjoint distribution in unit cells as well as on the reactivity worth were also examined for thermal systems.[4,5]

Ehud Greenspan

Nuclear Research Centre-Negev
Physics Department
P.O. Box 9001
Beer Sheva, Israel

December 8, 1982

[1]K. S. SMITH, *Nucl. Sci. Eng.*, **81**, 451 (1982).

[2]P. E. McGRATH and E. A. FISCHER, "Calculations of Heterogeneous Fluxes, Reaction Rates and Reactivity Worths in the Plate Structure of Zero Power Fast Critical Assemblies," KFK-1557, Karlsruhe Nuclear Research Center (1972); see also *Proc. Topl. Mtg. Mathematical Models and Computational Techniques for Analysis of Nuclear Systems*, Ann Arbor, Michigan, April 8-11, 1973, CONF-730414, p. VII-0, U.S. Department of Energy (1973).

[3]E. GREENSPAN, "Developments in Perturbation Theory," *Advances in Nuclear Science and Technology*, Vol. 9, Academic Press, Inc., New York (1976).

[4]E. GREENSPAN and K. B. CADY, *Trans. Am. Nucl. Soc.*, **9**, 242 (1966).

[5]E. GREENSPAN and K. B. CADY, *Trans. Am. Nucl. Soc.*, **9**, 243 (1966).

Response to "Comments on 'The Effects of Intracell Adjoint Flux Heterogeneity on First-Order Perturbation Reactivity Calculations' "

The references cited in Ref. 1 are both interesting and relevant to the effects of heterogeneity on reactivity calculations. There are many methods by which one can treat adjoint flux heterogeneities. The primary thrust of the original article[2] was to establish the magnitude of the errors that are introduced when flux-weighted cross sections are used to compute sample reactivities. The reasons for which the particular method of correcting for adjoint flux heterogeneities was chosen are in part due to the particular methods by which sample reactivities are measured.

In recent experiments,[3] sample reactivities have been measured by placing small foils between the plates that comprise a unit cell. In so doing, the worth of a sample can be measured at various positions in a cell as well as spanning the cell. This approach produces information that is directly related to the spatial distribution of adjoint flux within the cell. This information can be compared directly to the calculated worth distributions using the methods outlined previously. If bilinear flux weighting methods, for example, are used to account for such effects, one must generate cross sections (for each isotope) for every position of interest within the cell and then compute sample reactivities with each set of cross sections. Such an approach will produce the desired results, but it is somewhat tedious and obscures much of the physical insight that can be gained by examining the detailed first-order perturbation worth distributions obtained from cell calculations.

Kord S. Smith

Argonne National Laboratory
P.O. Box 2528
Idaho Falls, Idaho 83401

January 21, 1983

[1]EHUD GREENSPAN, *Nucl. Sci. Eng.*, **84**, 74 (1983).

[2]K. S. SMITH, *Nucl. Sci. Eng.*, **81**, 451 (1982).

[3]R. W. SCHAEFER and R. G. BUCHER, "Calculated and Measured Reactivities in the U9 Critical Assemblies," *Proc. Topl. Mtg. Advances in Reactor Physics and Core Thermal Hydraulics*, Kiamesha Lake, New York, September 22-24, 1982, Vol. 2, p. 93, available from the National Technical Information Service (1982).