

“Current Status and Future Directions of Neutronics Methods for Reactor Core Stimulation”

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ABSTRACT

The current generation of core neutronics methods is based on nodal diffusion theory and utilizes homogenized cross sections and other physics data generated by lattice depletion (fuel burnup) codes based on transport theory calculations. This reactor analysis methodology was developed and refined for the currently operating class (Generation II) of light and heavy water reactors (LWR or HWR). Until about one to two decades ago, the reload cores of these reactors were designed with relatively homogeneous distributions of fuel, moderator, and absorber materials. For these systems, core-level diffusion theory is a good approximation, and the computational de-coupling of fuel assemblies for generating physics data is acceptable.

The trend toward compositional heterogeneity in LWRs and desire for deep fuel burn including actinides in the Generation IV thermal and fast reactor class will lead to cores with higher neutron flux gradients. In these systems, the neutron leakage between adjacent assemblies is generally significant and cannot be neglected. Generating physics data using single lattice transport calculations, as is done with current core neutronics methods, may lead to substantial errors in the homogenized cross sections and discontinuity factors. Without accurate data, the simplified nodal core model will produce inaccurate results. This is the consequence of the computational de-coupling of a highly coupled system.

Non-LWR Generation IV reactor designs such as the fast burner reactor are likely to be so different from current LWRs that they will necessitate a different and much smaller set of assumptions on which to base core neutronics and fuel burnup models. The desire to burn used nuclear fuel (e.g., actinides) will particularly make core level isotopic tracking of utmost importance and significantly more difficult than the current lattice depletion methods. It is clear that the next generation of reactor analysis methods will have to be based largely on pure transport theory (both at the fuel burnup and core levels) and involve fewer approximations regarding the nature of the core system than current methods. Diffusion theory and the multitude of methods based on transport corrections to diffusion theory will not be sufficient to support the optimum design, operation, and monitoring of the next two generations of reactor systems for the reasons delineated above. A computationally efficient core-wide transport theory method would provide a highly accurate and flexible (i.e. applicable to a much broader class of systems) neutronics and fuel burnup module of a nuclear reactor simulator.

A new hybrid (stochastic/deterministic) coarse mesh radiation transport method under development at Georgia Institute of Technology for whole reactor core simulation will be briefly discussed in this presentation.

REFRESHMENTS WILL BE SERVED