NUCLEAR ENERGY RESEARCH INITIATIVE

An Advanced Integrated Diffusion/Transport Method for the Design, Analysis, and Optimization of Very High Temperature Reactors

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Project Number: 07-003

Program Area: Generation IV

Project Description

The Very High Temperature Reactor (VHTR) requires new computational methods for the design and evaluation of the reactor core. Designs such as the Pebble Bed Reactor (PBR) require the presence of control rods in the reflector region. Traditional nodal diffusion methods will not accurately model these regions because diffusion theory breaks down in the vicinity of high neutron absorption and steep flux gradients. Therefore, an integrated diffusion/transport method is being proposed. This method will use a local transport solver based on a new incident flux response expansion method in the controlled nodes that does not rely on spatial homogenization. Conventional diffusion theory will be used in the rest of the core. This approach will improve the accuracy of the core solution by generating transport solutions of controlled nodes while maintaining computational efficiency by using diffusion solutions in nodes where such a treatment is sufficient. The transport method will initially be developed and coupled to the reformulated 3-D nodal diffusion model in the PEBBED code for PBR core design and fuel cycle analysis.

The development of this methodology extends to other VHTR technologies, such as the prismatic VHTR. In this case, the method can be used to accurately capture transport effects in highly heterogeneous regions with steep flux gradients. The calculations of these nodes with transport theory will avoid errors associated with spatial homogenization.

Workscope

This project will accomplish the following primary objectives:

- Develop, implement, and test the 2-D cylindrical coupled diffusion/transport method (IDT) using the response function-based transport method integrated into PEBBED
- Extend, implement, and test the IDT method in 3-D cylindrical geometry utilizing the response function-based transport method integrated into PEBBED
- Adapt the 2-D Cartesian transport solver to generate response function-based solutions in hexagonal geometries and integrate with a reputable diffusion code (e.g., DIF3D)