WHOLE CORE TRANSPORT CALCULATION FOR THE VHTR HEXAGONAL CORE

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ABSTRACT

Recently, the DeCART code which performs the whole core calculation by coupling the radial MOC transport kernel with the axial nodal kernel has equipped a kernel to deal with the hexagonal geometry and applied to the VHTR hexagonal core to examine the accuracy and the computational efficiency of the implemented kernel. The implementation includes a modular ray tracing module based on the hexagonal assembly and a multi-group CMFD module to perform an efficient transport calculation. The requirements for the modular ray are: (1) the assembly based path linking and (2) the complete reflection capabilities. The first requirement is met by adjusting the azimuthal angle and the ray spacing for the modular ray to construct a core ray by the path linking. The second requirement is met by expanding the constructed azimuthal angle in the range of [0,30°] to the remained range to reflect completely at the core boundaries. The considered reflecting surface angles for the complete reflection are 30n's (n=1,2,...,12). The CMFD module performs the equivalent diffusion calculation to the radial MOC transport calculation based on the homogenized structure units. The structure units include the hexagonal pin cells and gap cells appearing at the assembly boundary. Therefore, the CMFD module is programmed to deal with the unstructured cells such as the gap cells. The CMFD equation consists of the two parts of (1) the conventional FDM and (2) the current corrective parts. Since the second part of the CMFD equation guarantees the reproducibility of the radial MOC transport solutions for the cell averaged reaction rate and the net current at the cell surfaces, how to build the first part of the CMFD equation is not important. Therefore, the first part of the CMFD equation is roughly built by using the normal distance from the gravity center to the surface.

The VHTR core uses helium as a coolant which is realized as a void hole in a neutronics calculation. This void hole which occupies several cells has no influence on the MOC transport calculation, but it introduces a near singular matrix for a CMFD formulation. This void problem is resolved by introducing a lumped CMR scheme in which the void cells are collapsed to one equation to produce one rebalancing factor. The lumped CMR scheme causes the original CMFD equation not to converge. Therefore, the CMFD calculation is stopped if the residual error of the CMFD solution does not reduce, and return to the radial MOC transport calculation.In the comparison of the computational result with the MCNP code for the VHTR 2-D core problem, DeCART shows about 200 ~ 500 pcm difference in the eigenvalue, and less than 1.0 % difference in the assembly power distribution. For the computing time, DeCART takes less than 5 hours on a PENTIUM-IV 3.0 GHz personal computer. Those results indicated that the hexagonal module of the DeCART code worked very well within an affordable computing time.