Dancoff Calculations for PBMR Fuel Using TransLAT 3-D Lattice Code

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INTRODUCTION

The increasing interest in High Temperature and Pebble Bed Modular Reactors has fueled a need for codes which are able to handle spherical fuel. Often, the methodology for Light Water Reactors with cylindrical fuel cannot be applied to the spherical fuel. In many codes it is not even possible to model the PBMR spherical fuel elements made of thousands of spherical fuel kernels. Currently, Monte Carlo methods are used to model spherical fuel, but TransWare Enterprises Inc. has developed a 3-D deterministic method as an alternative.

TransLAT [1] 3-D lattice physics software uses integral transport theory methods and 3-D arbitrary geometry techniques to solve neutron flux, gamma flux, and eigenvalue problems. This paper addresses the calculation of the infinite Dancoff factor for the spherical fuel kernels in the PBMR fuel assembly using TransLAT. The results from the TransLAT calculation are compared to the analytical results presented by Bende et al [2].

DESCRIPTION OF WORK

The Dancoff factor is the probability that a neutron leaving one absorber region does not have any collision in the moderator before it reaches another fuel region. The Dancoff factor for each absorber region is calculated using 3-D arbitrary geometry ray-tracing techniques. TransLAT uses a 3-D ray-tracing methodology to determine the Dancoff interactions for arbitrary positioned and shaped fuel regions. All the rays going out of each absorber region are followed through the moderator until they reach another fuel region. The transmission probabilities are integrated along these paths and the Dancoff factor is the sum of the probabilities due to the rays leaving that region.

The Dancoff factors are calculated for an infinite cubic lattice of fuel kernels surrounded by a graphite box. The kernels are the same TRISO particles as described in Reference 2 which consist of a fuel sphere surrounded by four layers of coating. The fuel spheres have a radius of 250 μ, and the coating layers all contain carbon in some form with thicknesses of 95, 40, 40, and 35 μ. The fuel and each carbon layer are modeled explicitly in TransLAT. Calculations are performed for twelve kernel densities within the fuel zone of the pebble ranging from 5000 to 60000 kernels. The dimensions of the graphite box surrounding the kernel are calculated by dividing the volume of the 2.5 cm radius pebble fuel zone by the number of kernels in each pebble. This unit cube is modeled in TransLAT with reflective boundary conditions.

RESULTS

The results from the Dancoff calculation with TransLAT are given in Figure 1 together with the analytical results calculated by Bende et al. The agreement is around 1% for all kernel densities greater than 10,000. The TransLAT results are 7% lower for the 5000 kernel problem. However, it was reported by Bende et al that the analytical results were 4% higher than the results from MCNP. This suggests that the results with TransLAT are within 3% of the MCNP calculation for the 5000 kernel problem.

CONCLUSIONS

The results obtained with TransLAT are in excellent agreement with the results from Bende et al. The next step is to model a pebble containing the kernels to determine the non-infinite Dancoff factors. This will then lead to the eigenvalue calculation for the complete system of fuel and moderator pebbles.

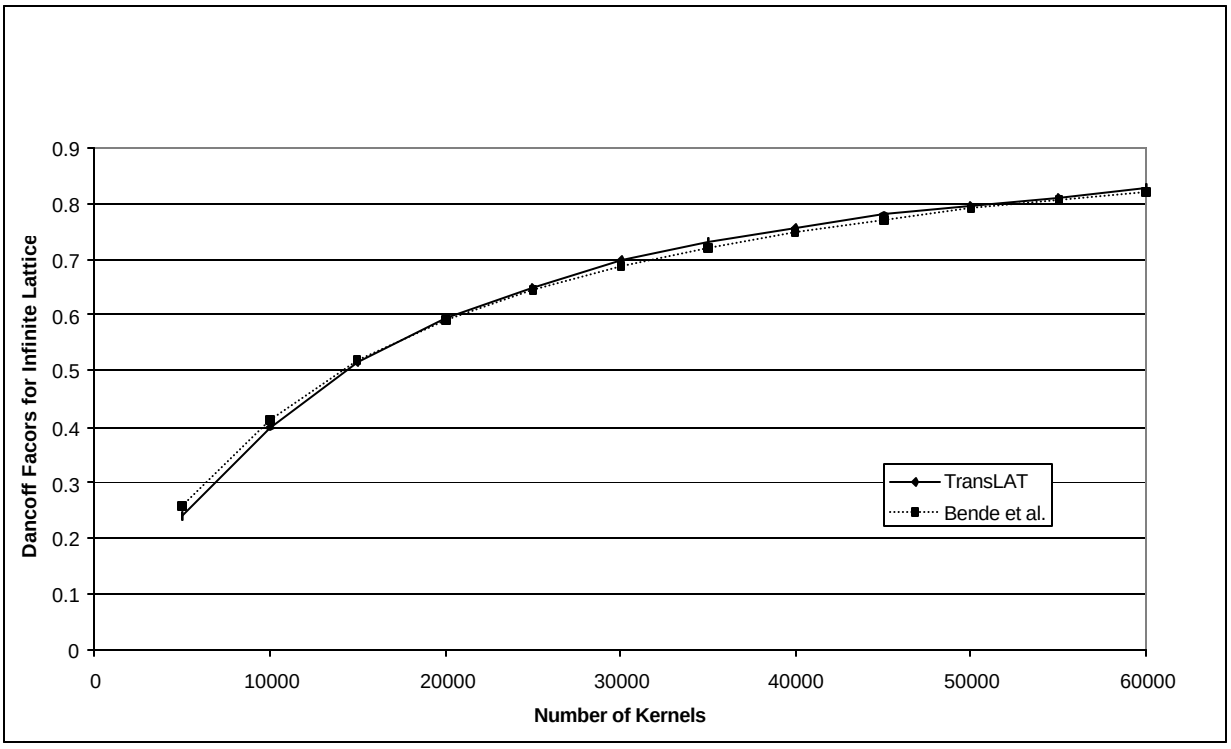

Figure 1 Dancoff Factor Versus Kernel Density

REFERENCES

1. TransLAT 3-D Lattice Physics Software, TransFX Computer Software Manuals, TWE-TFX-001, June 2001.

2. E.E. Bende, A.H. Hogenbirk, J.L. Kloosterman, and H. van Dam, "Analytical Calculation of the Average Dancoff Factor for a Fuel Kernel in a Pebble Bed High-Temperature Reactor," *Nucl. Sci. Eng.*,**133**, 147 (1999).