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INTRODUCTION

The INSTANT code is a full-core transport code being developed at Idaho National Laboratory [1]. It utilizes the most modern computing techniques to generate a neutronics tool of full-core transport calculations for reactor analysis and design. It can perform calculations on unstructured 2D/3D triangular, hexagonal and Cartesian geometries. Calculations can be easily extended to more geometries because of the independent mesh framework coded with the model Fortran. This code has a multigroup solver with thermal rebalance and Chebyshev acceleration. It employs second-order PN and Hybrid Finite Element method (PN-HFEM) discretization scheme. Three different in-group solvers – preconditioned Conjugate Gradient (CG) method, preconditioned Generalized Minimal Residual Method (GMRES) and Red-Black iteration – have been implemented and parallelized with the spatial domain decomposition in the code. The input is managed with extensible markup language (XML) format. 3D variables including the flux distributions are outputted into VTK files, which can be visualized by tools such as VisIt and ParaView. An extension of the code named INSTANT-HPS provides the capability to perform 3D heterogeneous transport calculations within fuel pins.

C5G7 is an OECD/NEA benchmark problem created to test the ability of modern deterministic transport methods and codes to treat reactor core problems without spatial homogenization [2]. This benchmark problem had been widely analyzed with various code packages. In this transaction, results of the applying the INSTANT-HPS code to the C5G7 problem are summarized.

PROBLEM DESCRIPTION

The problem chosen for this analysis is the two-dimensional C5G7 benchmark problem with quarter core symmetry. Figure 1 shows the configuration of the 2D C5G7 problem. The overall dimensions of the 2D configuration are 64.26 x 64.26 cm, while each assembly is 21.42 x 21.42 cm. Reflected boundary conditions are applied to the top and left of the geometry while vacuum boundary conditions are applied to the right and bottom of the geometry. Each fuel assembly is made up of a 17 x 17 lattice of square pin cells. The detailed description of the benchmark problem can be found in reference [2].

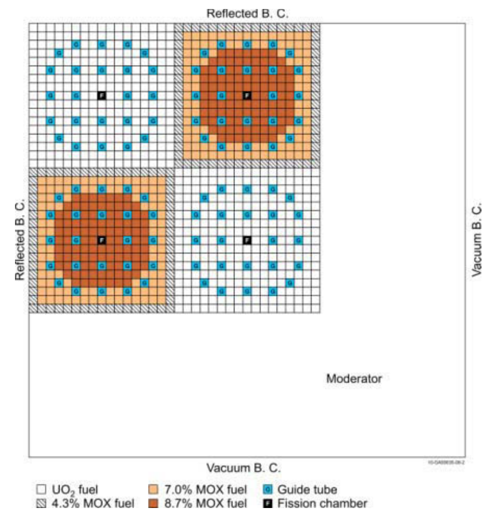

Fig. 1. Configuration of the 2D C5G7 Problem

ANALYSIS RESULTS AND DISCUSSION

The geometry described with the XML is triangulated by Triangle [3] within INSTANT-HPS. Mass of each fuel pin is preserved during the triangulation. Part of the mesh is illustrated in Figure 2. So far the second-order PN transport solver is the only one available in INSTANT-HPS and has been very successful on nodal calculations. Complete polynomial basis functions are used to discretize the interior even flux and the interface odd flux. Uniform interior polynomial order of 6 and interface polynomial order of 2 are used in this study. Eigenvlaues for P1 through P5 presented in Table I are obtained with sufficient convergence criteria. The reference eigenvalue is 1.186550 [2].

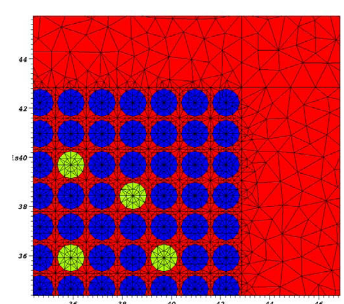

Fig. 2. Illustration of the mesh for the 2D C5G7 problem

Table I. Eigenvalues and eigenvalue percent errors based on results from INSTANT-HPS

Legendre Order	Eigenvalue	Percent Error
1	1.183249	-0.278
3	1.183130	-0.288
5	1.183110	-0.290

The eigenvalue results are consistent with those previously calculated using another general-purpose finite-element spherical harmonics code EVENT [4].

PN-HFEM solver requires explicitly assembling the matrices for all elements with different geometry sizes and different materials. When the unstructured mesh is employed, these matrices put a stringent constrain on computer memory requirement. The situation becomes worse because of no memory optimization available for an irregular-shaped element. The memory requirement increases dramatically with PN order. Additionally, the solution converges with PN slowly. Memory requirement remains an issue with parallelization while CPU time is not. Due to these limitations, a new transport solver based on the second-order SN equation is under development.

ACKNOWLEDGMENTS

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