Best Poster Award

Physor 2008

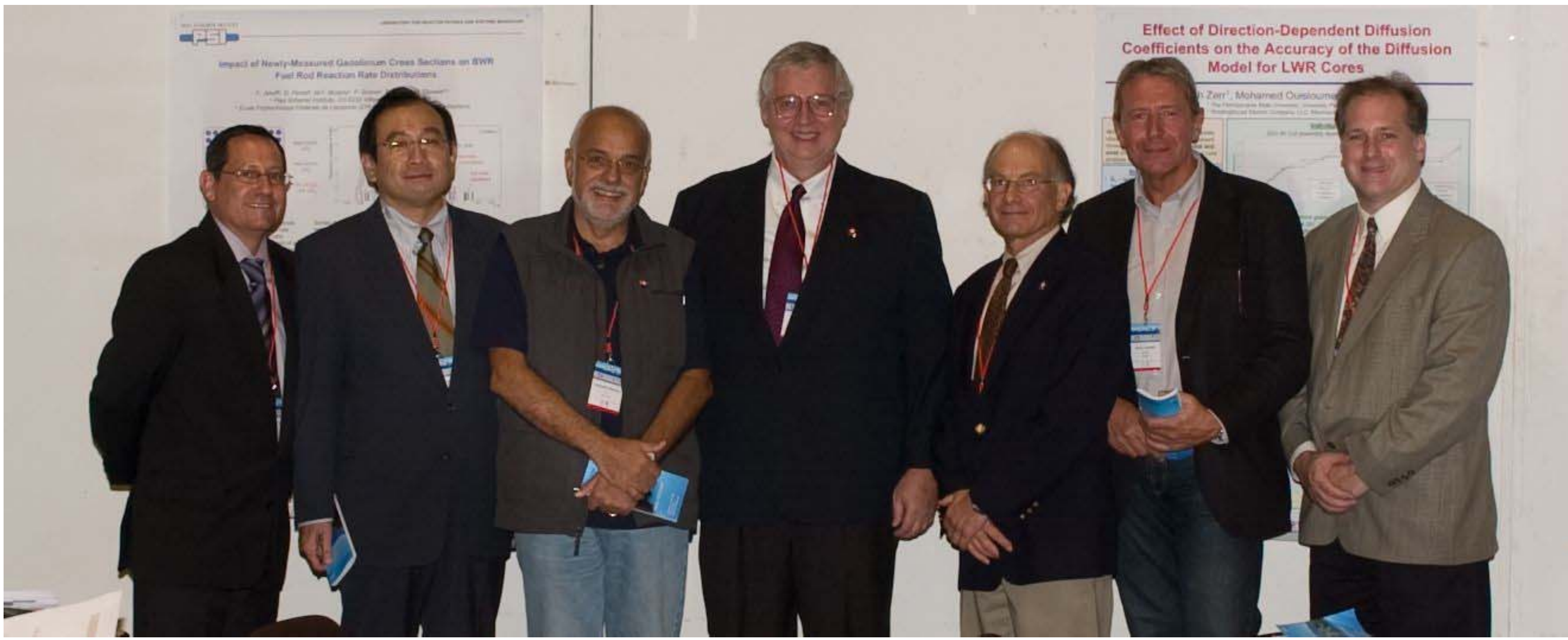
September 14-19, 2008

Interlaken, Switzerland

Committee Assignment

Select the three best posters in order for Physor-2008

Poster Award Committee



Poster Evaluation

The Committee evaluated each poster on the quality and effectiveness of the:

- ✓Paper
- ✓Poster
- ✓Presentation

Honorable Mention

- Fission rate distribution at the 84-pin radial selection of a SVEA-96 Optima2 BWR assembly

G. Perret, M.F. Murphy, F. Jatuff (PSI, Switzerland)

R. Chawla (EPFL PSI, Switzerland)

Honorable Mention

- MARBLE: a next generation neutronics analysis code system for fast reactors

K. Yokoyama (JAEA, Japan),

Y. Hirai, M. Tatsumi, H. Hyoudou (Nuclear Fuel Industries, Japan)

G. Chiba, T. Hazama, Y. Nagaya, M. Ishikawaa (JAEA, Japan)

First Second Place Poster

Effect of Direction-Dependent Diffusion Coefficients on the Accuracy of the Diffusion Model for LWR Cores

R. Joseph Zerr[1], Mohamed Ouisloumen[2], Yousry Azmy[1]
[1] The Pennsylvania State University, University Park, PA, USA
[2] Westinghouse Electric Company, LLC, Monroeville, PA, USA

Motivation

•BWR moderator density decreases axially
•Axial streaming becomes more prominent
•Investigate the impact of using **radial and axial** diffusion coefficients (DCs) in the core analysis diffusion models

Diffusion Coefficients

- B_1 – isotropic values; typically homogenized regions
- TIBERE module of DRAGON code – based on directional leakage formula

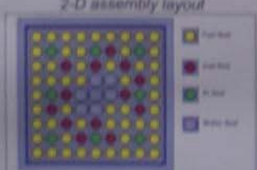
$$L = \int_{cell} \nabla \cdot \vec{J} dV = (D_r B_r^2 + D_z B_z^2) \int_{cell} \phi(\vec{r}) dV$$

- Previous work demonstrated direction-dependent diffusion coefficient (DDDC) utility for localized voiding – maintain spatial heterogeneity
- This work generates the DDDCs of assemblies with varying moderator density
- Apply spatially homogenized DDDCs to diffusion calculations

Benchmark Configurations

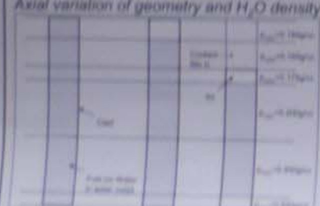
1. 9×9 BWR assembly, 6 2-D layers of varying moderator density, all reflective boundary conditions
   - 172-group nuclear data in DRAGON vs. MCNP continuous-energy
   - Multi-group data condensed to 2-group for 3-D diffusion calculations

2-D assembly layout



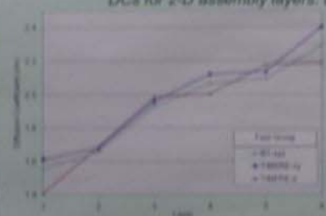
2. 3-D assembly with 6 homogenized layers
3. 2x2 checkerboard 3-D mini-core of fresh/depleted assemblies

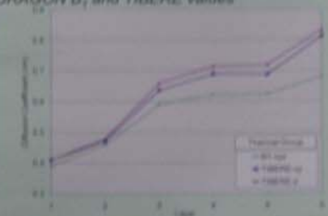
Axial variation of geometry and H_2O density



Individual Layer Results

DCs for 2-D assembly layers: DRAGON B_1 and TIBERE values





- Fast group leakage > thermal group leakage
- Z-direction DC > the radial DC
- Air macro-regions have high radial leakage in the surrounding micro-regions, affecting homogenized DCs
- B_1 DCs agree better with TIBERE DDDCs for less voided, anisotropic regimes
- DRAGON execution time increases ~4X—computation of directional reduced collision probabilities

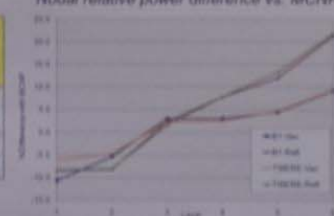
3-D Assembly Results

- Assembly tested with vacuum and reflective boundary conditions at top and bottom surfaces
- Assembly eigenvalue and nodal power results indicate that single-DC and DDDC data sets provide comparable accuracy versus MCNP reference

Eigenvalue difference vs. MCNP

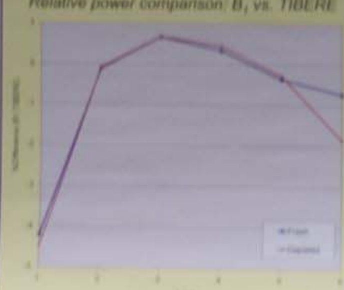
Top/Bottom BC	B_1 DC data	TIBERE DDDC data	MCNP Ref.
Vacuum pcm/σ	1.03516 52	1.03504 41	1.03462 (0.00028)
Reflective pcm/σ	1.03686 -33	1.0368 -39	1.3072 (0.00028)

Nodal relative power difference vs. MCNP



3-D Mini-Core Results

Relative power comparison: B_1 vs. TIBERE



- Only small differences in nodal power between two data sets
- Small difference in eigenvalues between the two data sets for both top/bottom vacuum and reflective boundary conditions—10s of pcm.

Conclusions

•DDDCs do not provide significant gains in accuracy for BWR diffusion analysis when homogenized over entire assembly
•Better suited for more accurate analysis of heterogeneous, localized regions

- Effect of direction-dependent diffusion coefficients on the accuracy of the diffusion model for LWR cores

R.J. Zerr (Pennsylvania State Univ., USA)

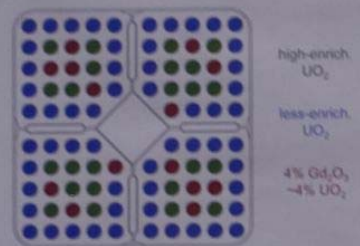
M. Ouisloumen (Westinghouse, USA)

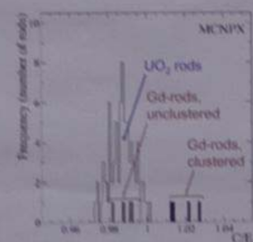
Y. Azmy (Pennsylvania State Univ., USA)

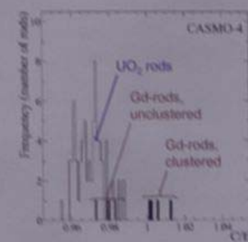
Second Second Place Poster

Impact of Newly-Measured Gadolinium Cross Sections on BWR Fuel Rod Reaction Rate Distributions

F. Jatuff[a], G. Perret[a], M.F. Murphy[a], P. Grimm[a], R. Seiler[a], R. Chawla[a,b]
[a] Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland
[b] Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland





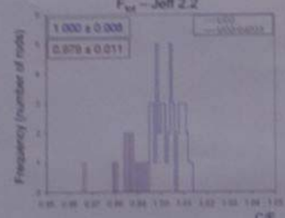


During LWR-PROTEUS, specific trends were identified in the total fission rate (F_{tot}) and modified conversion ratio (C_8/F_{tot}) of the gadolinium (Gd) rods of a SVEA-96+ fuel assembly, different from the trends observed in UO_2-only.

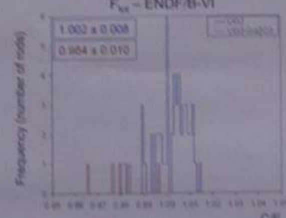
Similar discrepancies have also been observed in other experimental programmes such as BASALA in France.

Material and geometrical effects, as well as thermalization models, could not explain these discrepancies; however new cross sections are now available...

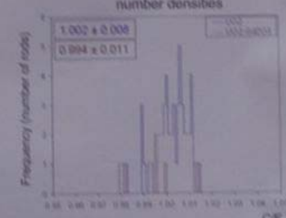
F_{tot} – Jeff 2.2



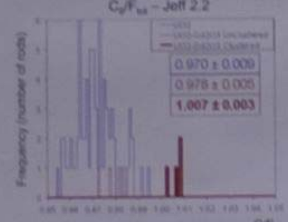
F_{tot} – ENDF/B-VI



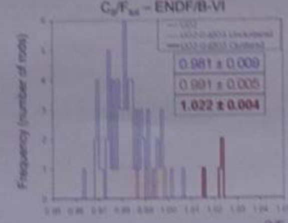
F_{tot} – ENDF/B-VI, Modified Gd number densities



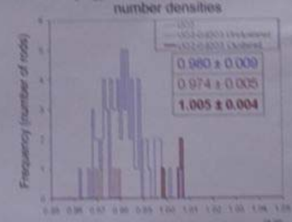
C_8/F_{tot} – Jeff 2.2



C_8/F_{tot} – ENDF/B-VI



C_8/F_{tot} – ENDF/B-VI, modified Gd number densities



- Preliminary studies indicate that cross section effects are sufficient to explain Gd-pin reaction rate and reaction rate ratio discrepancies as measured during the LWR-PROTEUS programme, to the point of making Gd-rod trends undistinguishable from UO_2-rod trends.
- The newly-measured Gd cross sections have not yet been verified by the nuclear data community and thus have not yet been incorporated in ENDF/B-VII.0; efforts are currently on-going to produce cross sections for different codes (e.g. MCNPX) to expand and confirm the results from these preliminary studies in the context of the VENUS-EOLE-PROTEUS collaboration in western Europe.

Acknowledgments
The LWR-PROTEUS programme was conducted jointly by PSI and the Swiss Nuclear Power Plants (swissnuclear). We are particularly indebted to H. Fuchs and P. Hirt (Aare-Tessin AG für Elektrizität), D. Furtado and U. Georg (Kernkraftwerk Mühleberg), J. Krouthén and T. Williams (Nordostschweizerische Kraftwerke), J. Hadermann [illegible] for their strong support of these experiments and analyses.

- Impact of newly-measured gadolinium cross-sections on BWR fuel rod reaction rate distributions

F. Jatuff, G. Perret, M. Murphy, P. Grimm, R. Seiler (PSI, Switzerland)

R. Chawla (EPFL PSI, Switzerland)

Best Poster

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PHYSOR'08

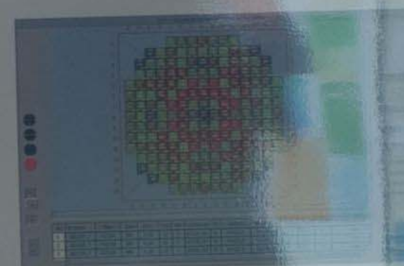
Loading pattern optimization using ant colony algorithm

Problem overview

Every 12 or 18 months, nuclear reactors have to be loaded with fresh fuel to replace the most burnt fuel assemblies. The arrangement of assemblies within the core (the loading pattern) is a complex operation since many operational constraints have to be satisfied. The main safety constraints are:

- *Maximum pin power*
- Positioning constraints
- Shut-down margin

EDF R&D supplies EDF core design engineers with tools that assist them through the search process, including automatic loading pattern optimization tools.

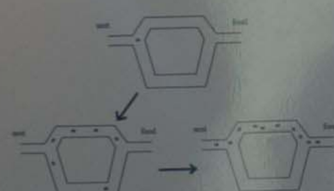


Description of Ant Colony Algorithms

Ant Colony Algorithms are recent population-based methods (like genetic algorithms) that have given very good results on combinatorial optimization problems (Dorigo et al, 2000).

Real ants use pheromones to communicate and the typical problem solved by a real ant colony is to find the shortest path from the nest to a food source (see fig. below).

In Ant Colony Algorithms, artificial ants use artificial pheromone trails to aggregate all the information accumulated by each individual ant.



Application to loading pattern optimization

The algorithm for loading pattern optimization is as follows:

- Pheromone trails are initialized
- While the termination condition is not satisfied:
  - Each ant builds a loading pattern (LP)
  - Each LP is evaluated by COCCINELLE, the reference core code of EDF
  - Pheromone evaporates
  - The pheromone trails are updated by using the best LP of the iteration

Tests and results

A mock-up program that optimizes LPs by using a variant of Ant Colony Algorithm has been developed. Tests on realistic cases are performed using 200 iterations and a colony of 24 ants, for a total of 4800 core evaluations. It gives similar results to those of LOOP, an industrial optimization tool based on simulated annealing and which typically performs 30,000 core evaluations during its search process.

Future research

These encouraging results can be improved by focusing on :

- Hybridization of the ant algorithm with local search methods (quality of solutions)
- Parallelization of core calculations (speedup)

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EDF R&D

- Loading pattern optimization using ant colony algorithm

F. Hoareau (EDF, France)

Congratulations!

- To the winners
- To everyone who worked very hard on preparing and presenting your posters
- To the participants for your interest in the poster presentations

THANK YOU!!