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Validation of Improved 3D ATR Model

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INTRODUCTION

A full-core Monte Carlo based 3D model of the Advanced Test Reactor (ATR) was previously developed. [1] An improved 3D model has been developed by the International Criticality Safety Benchmark Evaluation Project (ICSBEP) to eliminate homogeneity of fuel plates of the old model, incorporate core changes into the new model, and to validate against a newer, more complicated core configuration. This new 3D model adds capability for fuel loading design and azimuthal power peaking studies of the ATR fuel elements.

MCNP MODELING

The ATR, located at the Idaho National Laboratory is a 250 MW (thermal) high flux test reactor designed 1) to study irradiation effects on reactor/fuel materials, 2) to generate radioisotopes for medical/research application, and 3) to irradiate cobalt target capsules. The ATR contains forty fuel elements arranged in a serpentine fashion to form flux traps (see Fig. 1). The fuel element consists of nineteen curved plates of different widths, attached to side plates forming a 45 degree sector of a circular annulus. The fuel meat contains highly enriched (93%) uranium-aluminide fuel powder dispersed in aluminum powder. The fuel elements are moderated by light-water, and reflected by beryllium.

The full-core model was developed using MCNP [2]. In the new model, each of the forty fuel elements was represented by 117 radial and 5 axial regions. The borated fuel plates 1 – 4 and 16 – 19 as well as the non-borated plates 5 – 15, were explicitly modeled. The arcuate fuel meat, cladding, non-fuel regions next to the meat, side plates, and water gap between fuel elements were explicitly modeled. Various irradiation holes and fillers in the core were explicitly modeled. New irradiation facilities were added in the new model. The new model was validated against a critical core configuration achieved in 1994. This critical core contains fresh fuel elements and cobalt target loadings in the Northeast, Center, East, and South flux traps, and a fresh beryllium reflector, which were explicitly modeled. The outer shim control cylinders were set to 51.8 degrees, and all of the safety rods were fully withdrawn. All of the shims rods, except two regulating rods, were fully inserted in the critical core configuration.

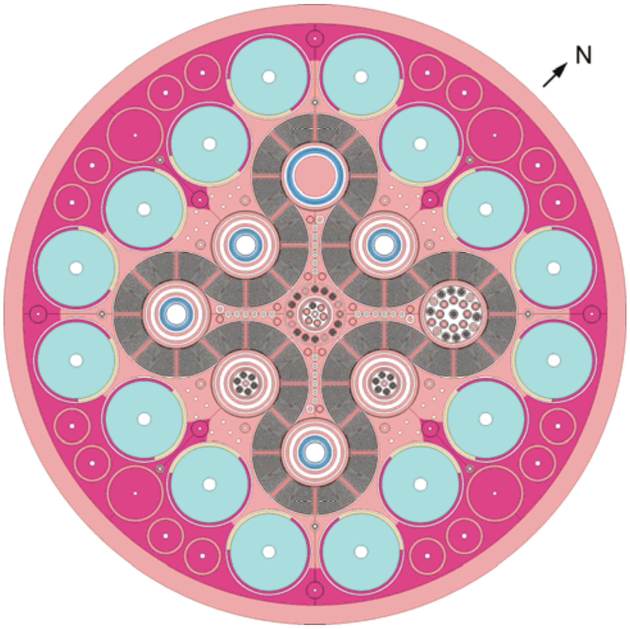

Fig. 1. Plan View of the 3D ATR Model.

RESULTS

The MCNP calculated k_{eff} for the 1994 critical core was 0.99875 ± 0.00034, which is 0.1% subcritical. Fig. 2 compares normalized fuel element power for each of the forty fuel elements. In general, good agreement was observed between measurement data and MCNP calculated data. The uncertainty in the fuel element power measurements was ± 1.5%. Calculated lobe powers were within 4.3% of the measured data. The MCNP element powers were compared with PDQ [3] results. The results from the two codes agreed with each other with a maximum difference of 6.7%. Extensive sensitivity calculations were performed to determine material effects and geometric uncertainties of various core components on k_{eff}. The sum of the uncertainties is calculated to be 0.24 $\%\Delta k_{eff}$.

The detailed model developed and documented through the ICSBEP project provides valuable data for ATR programs. The full-core model can be used for physics analysis of asymmetric experiment loading in the core, and now for new fuel loading design and azimuthal power peaking studies of the ATR fuel elements.

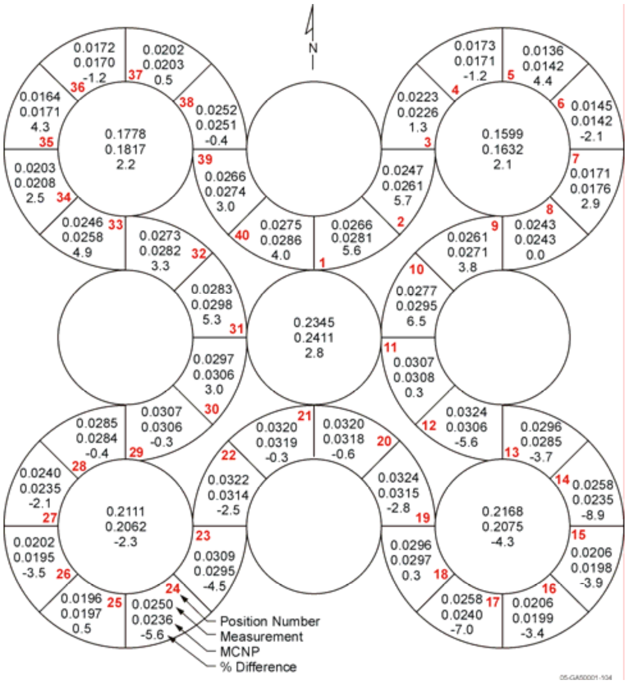

Fig. 2. Normalized Element Power Comparison between MCNP and Measurement Data.

REFERENCES

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