Safety Analysis Support for the USGS Research Reactor
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Work this December involved what should be the final step in correcting the MCNP model before analysis begins. Aside from the bias caused by the neutron libraries discussed in previous reports, the simulated control rods had insufficient reactivity worth when partially inserted, leading to a large positive bias in k_{eff} in the analysis. This problem resulted from the modeling of the control rods as a single regions, depleting the boron absorber equally throughout the rod. Figure 1 shows the experimental and predicted rod worth curve for the shim 1 rod. When the rod is modeled as a single axial region the single rod has slightly too much reactivity worth when mostly withdrawn and significantly too little worth over most of the rods operating range when partially inserted (the rod position in Figure 1 is the height of the rod, so 0 is fully inserted and 1000 is fully withdrawn).

Splitting the control rod into four axial segments corrects this error. A tally calculated the average neutron flux in each segment of the rod with the rod at the experimentally determined critical position. Using this tally, the boron depletion was re-distributed in the rod segments proportional to the neutron flux in each segment, with higher depletions corresponding to higher fluxes. This led to the top-most portion of the rod becoming largely non-depleted, while the bottom-most portion of the rod became almost completely depleted.

Figure 1 presents the experimental data from the GSTR with the old one-segment and new four-segment predicted reactivity worths. Considering the model and experimental uncertainties, the four-segment alteration to the model results in a almost perfect match with the experimental results.

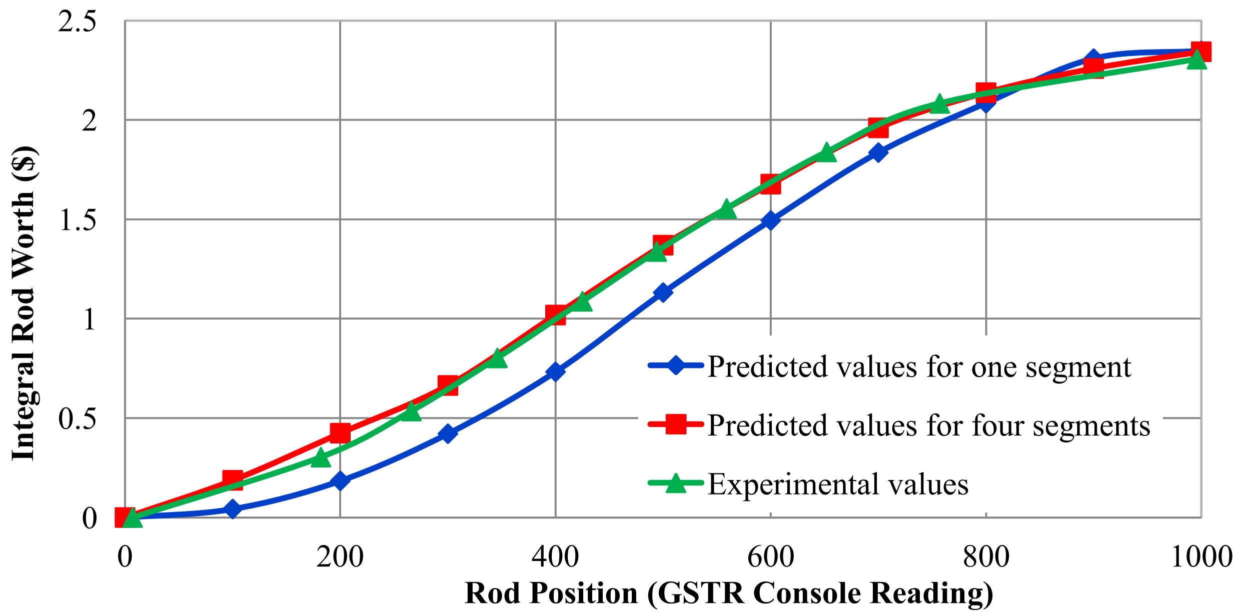

Figure 1. Shim1 rod reactivity worth curve showing the improvement in the model's predictive capability

In January we will alter the three remaining rods in accordance with this method, and re-calculate the final results for the low power model. This should resolve the remaining discrepancies, and lower the reactivity predicted by the model to an amount much closer to the experimental results from the GSTR.

After resolving these issues, the remaining neutronics analysis should take around two months. This includes a detailed analysis of the power profile within the hot rod of the GSTR for use in the thermal-hydraulic analysis, which will require a significant amount of computer time to minimize the uncertainties. The steady-state thermal-hydraulic model is complete pending the availability of this data; the transient thermal-hydraulic model will be developed during this time, using the PARET code to analyze the pulse behavior of the core. The first neutronic results should be available at the end of January, while most of the analysis, barring any further model improvements, should be available for review by the end of April.