Contribution ID: **159**   Type: **POSTER**

Analysis of the EBR-II SHRT-45R neutronics benchmark with ERANOS-2.0

Wednesday 28 June 2017 17:50 (1h 10m)

A Coordinated Research Project (CRP), initiated by the International Atomic Energy Agency (IAEA), consisted of benchmark calculations with the goal to analyze two of the Shutdown Heat Removal Tests performed in EBR-II, namely SHRT-17 and SHRT-45R. Test SHRT-45R concerned an Unprotected Loss Of Flow (UOLF) scenario. In this case, only the inherent feedback mechanisms due to the change of the temperatures are available to reduce the power of the reactor during the transient. The SHRT-45R benchmark thus included a neutronics benchmark, the goal of which was to establish the neutronic feedback coefficients to be used in the transient calculations. We used ERANOS-2.0 to calculate the feedback coefficients for SHRT-45R.

Since the standard cross section library of ERANOS-2.0 is outdated, we used our in-house cross section processing software to generate cross section libraries for SHRT-45R, based on JENDL-4.0, in 1968 and 33 energy groups. Our processing software consists of a script, coupling the various calculation steps to generate an ECCO library. Since the SHRT-45R also specified some special materials (e.g. "fissium" as well as lumped fission products), the necessary cross sections were determined with ERANOS.

The SHR-45R benchmark specifies 3 unique mixtures for each fuel and blanket assembly, and since there are about 400 assemblies in total, there more than 1200 unique mixtures to take into account. Since each mixture is "user defined" in this case, some custom routines were added to the ERANOS software to create and manage the necessary data sets (EDLs).

Core calculations were done with diffusion theory and transport theory and generally gave good results for the major parameters, i.e., the multiplication factor, Doppler feedback effect, as well as the effects of radial and axial expansion.

The power distribution showed large deviations in non-fuel assemblies compared to the benchmark values. It is generally believed that this is due to the treatment of the gamma ray transport.

Some weak points of ERANOS-2.0 were highlighted: the management of a large number of user-defined mixtures, the determination of uncertainty due to delayed neutron parameters, the inconsistent treatment of gamma transport, and issues related to the treatment of thermal expansion.

Overall, the benchmark analysis showed a generally acceptable performance of our cross section processing and core analysis methods.

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