ANALYSIS OF ROD REMOVAL TRANSIENT EXPERIMENTS IN VVER REACTORS AT ZERO POWER

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Within the context of the Fissile Materials Disposition Program of the U. S. Department of Energy we are analyzing rod removal transient experiments performed at the Kurchatov Institute in full-scale mockup of VVER reactors. The reactor of the experiment had a core composed of 163 hexagonal fuel assemblies of different enrichment, each one containing 312 fuel rods, 18 guide tubes for control rods or burnable poison and 1 instrument tube. The transients were started (via water inlet) in slightly (few cents) supercritical configurations with all the control rods withdrawn. After a few minutes control rods banks or individual control rods were first inserted and later withdrawn (returning to the initial state). Seven incore and two excore detectors followed the transients; the available experimental data are the relative time profiles of the nine detectors and the power distributions at steady state (critical state with the control rods withdrawn).

Because of the mild nature of the transients (very low power and no more than two $ reactivities) we decided to use a quasistatic approach. The time dependent flux is factorized into two terms: a function of phase space given by the solution of the static equation with parametric excitation, and a function of time given by the solution of the point kinetic equations with time dependent kinetics parameters (reactivities, generation time and delayed neutron effectiveness). The time dependent kinetic parameters are defined with the usual ratio of functionals, but involving the solutions of the direct and adjoint static equations with parametric excitation.

Multigroup cross sections for transport and diffusion theory calculations were generated for the DORT and BOLD-VENTURE codes that need AMPX format cross sections. Two approaches were followed: (1) very detailed models of each kind of assembly were used with the HELIOS code so average cross sections for each type of assembly were generated and then converted to the AMPX format, and (2) the AMPX system was used to generate the cross sections with cell (rather than assembly) models. The advantages of the spatial details of the first method are limited, for some applications, by the P_1 nature of the cross sections generated. Conversely the P_n (n arbitrary) nature of AMPX generated cross sections might be an advantage for deep penetration problems.

Due to the nature of the experiment, cold conditions, control rods withdrawn and critical state with water level, the power distributions, measured and calculated, are quite unusual with the inner part of the core heavily shielded. Measured power levels at the center of the reactor are almost 20 times smaller than similar regions at the periphery. A sensitivity analysis of the calculated power profile were made changing method of calculations (1-D and 2-D transport and diffusion methods), grid type (r-theta, triangular), number of groups and the n of the Pn expansion of the scattering cross sections. In general, it was difficult to reproduce the power profile in the inner region of the core.

The numerical integration of the time dependent part of the solution was made with the LSODE package using ENDF-V and VI delayed neutron data.