RATEN ICN Approach to Reactor Physics Analyses using Transport and Diffusion-based Methodologies

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RATEN ICN Approach to CANDU Reactor Physics Analyses using Transport and Diffusion-based Computer Codes

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ABSTRACT

The classical methodology for phenomenological modeling of CANDU nuclear reactors is based on integral transport at the cell and supercell levels and uses diffusion approximation at the level of the entire core. In order to avoid copyright issues when using proprietary software, the Reactor Physics, Nuclear Fuel Performance and Nuclear Safety Department of RATEN ICN has developed its own neutronic computer codes over the years. Due to the specific nature of the CANDU core, which contains both horizontal and vertical reactivity devices (RD) perpendicular to the fuel channels, a primary focus was the development of a supercell code, namely PIJXYZ, for calculating the incremental cross-sections of the reactivity devices. PIJXYZ employes a multi-group formalism and is capable of providing incremental cross-sections for CANDU RDs both in 7 energy groups and collapsed into two groups, to be subsequently used directly by core analysis codes. A second research path aimed at developing a calculation program within the two-group diffusion approximation for the neutronic characterization of the reactor core. This is the DIREN code, which solves the diffusion equation using the finite difference method, providing integral parameters of interest for economic and nuclear safety analyses, such as: average discharge burnup, refueling frequency and fuel consumption, core power and burnup distribution, maximum channel and bundle powers, axial distribution, and form factors. The purpose of this paper is to exemplify the application of the RATEN ICN methodology based on integral transport and diffusion to a generic CANDU 6 reactor. The modeling of the CANDU elementary lattice cell was performed using the WIMS code. The RD incremental cross-section generated using the PIJXYZ code are compared with those generated using the DRAGON transport code, developed at Polytechnique Montréal. The integral core parameters generated with DIREN are compared with those available in the literature provided by the RFSP-IST code—the industry-standard tool currently used in the design and operation of CANDU reactors. The performed comparisons demonstrate a fair agreement of the results at the supercell level and a very good agreement at the core level.