A new calculation code opens new possibilities in nuclear reactor modelling

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Research Scientist Jaakko Leppänen from VTT Technical Research Centre of Finland has developed a new calculation code in his doctoral thesis, for the modelling of neutron physics in nuclear reactors. The so-called Monte Carlo method used by Leppänen has not been widely used for the production of input parameters for three-dimensional reactor simulator calculations.

The Monte Carlo method is a basic tool in particle transport problems, and it is well suited for tasks requiring the detailed modelling of geometry and physics. The method has been used in reactor physics calculations for decades, and the applications have mainly been restricted by computer capacity. In Leppänen's thesis, the use of the method is extended to new applications, when input parameters for three-dimensional reactor simulator calculations are generated using a Monte Carlo based lattice code.

Nuclear reactor modelling is a complicated task that combines neutron transport theory and the thermal hydraulics of coolant flow through the reactor core. Because of the complicated physics of neutron interactions, it is not possible to approach the problem as a single, well-defined task. Instead, the solution proceeds in steps, starting from the interactions between neutrons and the target nuclei. The intermediate step in the solution is the so-called lattice calculation, in which the geometry is modelled at the fuel assembly level. The results are then used as input parameters for a three-dimensional reactor simulator calculation, which yields the reactor response under different operating conditions.

The presently-used deterministic lattice codes have been developed mainly for the needs of light water reactor modelling, and the applications are not easily extended to advanced fuel types and next-generation reactor systems. Development in nuclear technology may hence require development in the calculation methods as well. A transition from deterministic to Monte Carlo lattice codes along with increasing computer capacity seems like a natural step in this respect. The use of a Monte Carlo based lattice code also brings all the advantages of the calculation method, and most importantly, the same code can be used for modelling any fuel or reactor type without compromising the reliability of the results.

The new calculation code developed at VTT is at first intended as a research tool, to be used in parallel with current deterministic lattice codes. The comparison of two codes based on entirely different calculation methods increases the reliability of the analyses, which is reflected in fuel management and reactor safety studies. The new code can also be used in studies involving next-generation reactor technology, in which the current deterministic lattice codes may not be applicable.

Research Scientist Jaakko Leppänen has defended his doctoral thesis at the Helsinki University of Technology on 18 June 2007 with the subject "Development of a New Monte Carlo Reactor Physics Code". The opponent in the defence was Associate Professor Eduard Hoogenboom from Delft University of Technology, the Netherlands.

Source: VTT, Finland