Design of a flexible nuclear reactor simulator based on finite elements and parallel computing

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ABSTRACT

Recent developments in computer technology have allowed to model nuclear reactors in a very accurate way and within a reasonable time. The main variable of study in this kind of problem is the neutron flux which is directly related to the power generated in the reactor. For this reason it is crucial to know its behavior as a coupling with the others physical parameters.

Up to now, most simulators solve very simplified equations that lose spatial details in order to gain speed in calculation. A very good example of these approximations are the point kinetics equations [1], where the neutron flux is considered a scalar that depends only on time and not on space. In this case, for example, the spatial evolution of the xenon 135 [1], which has a direct impact on the power generation distribution, is not considered properly in this kind of scheme.

In this work we propose a different philosophy of simulators based on solving in real time the three dimensional neutron diffusion equation. For doing this, an efficient finite element code programmed on a parallel scheme and combined with the domain partition technique was implemented. The key part of the code uses the PETSc library [2] for solving the linear system of equations and the METIS library [3] for the domain partitioning. Moreover the design proposed was aimed to be capable of simulating a wide variety of nuclear reactors for industrial and academic purposes.

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