CASL, Westinghouse simulate neutron behavior in AP1000 reactor core

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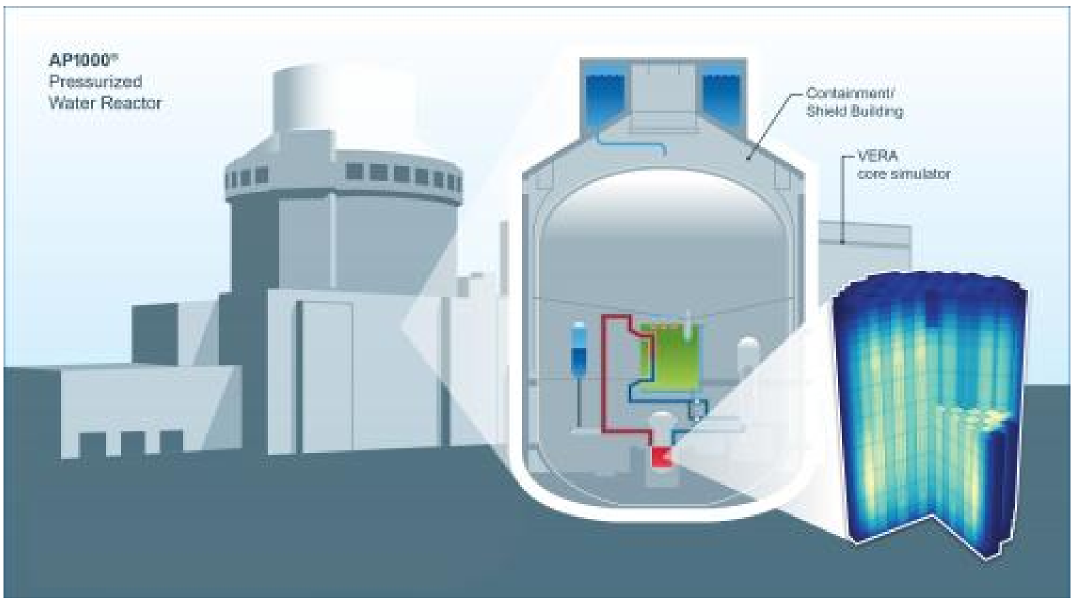

CASL is developing and applying new modeling and simulation technology (Virtual Environment for Reactor Applications Core Simulator or VERA-CS) to resolve and predict the detailed neutron distribution of the power-generation reactor core residing in reactor vessels. Credit: Westinghouse.

Scientists and engineers developing more accurate approaches to analyzing nuclear power reactors have successfully tested a new suite of computer codes that closely model "neutronics"—the behavior of neutrons in a reactor core.

Technical staff at Westinghouse Electric Company, LLC, supported by the research team at the Consortium for Advanced Simulation of Light Water Reactors (CASL), used the Virtual Environment for Reactor Applications core simulator (VERA-CS) to analyze its AP1000 advanced pressurized water reactor (PWR). The testing focused on modeling the startup conditions of the AP1000 plant design.

"In our experience with VERA-CS, we have been impressed by its accuracy in reproducing past reactor startup measurements. These results give us confidence that VERA-CS can be used to anticipate the conditions that will occur during the AP1000 reactor startup operations," said Bob Oelrich, manager of PWR Core Methods at Westinghouse. "This new modeling capability will allow designers to obtain higher-fidelity power distribution predictions in a reactor core and ultimately further improve reactor performance."

The AP1000 reactor is an advanced reactor design with enhanced passive safety and improved operational performance that builds on decades of Westinghouse's experience with PWR design. The first eight units are currently being built in China and the United States, and represent the first Generation III+ reactor to receive Design Certification from the U.S. Nuclear Regulatory Commission.

CASL is a U.S. Department of Energy (DOE) Innovation Hub established at Oak Ridge National Laboratory, a part of DOE's National Laboratory System. The consortium core partners are a strategic alliance of leaders in nuclear science and engineering from government, industry and academia.

"At CASL, we set out to improve reactor performance with predictive, science-based, simulation technology that harnesses world-class computational power," said CASL Director Doug Kothe. "Our challenge is to advance research that will allow power uprates and increase fuel burn-up for U.S. nuclear plants. In order to do this, CASL is meeting the need for higher-fidelity, integrated tools."

During the first generation of nuclear energy, performance and safety margins were held at conservative levels as industry and researchers gained experience with the operation and maintenance of what was then a new and complex technology. Over the past 50 years, nuclear scientists and engineers have gained a deeper understanding of the reactor processes, further characterizing nuclear reactor fuel and structure materials.

By making use of newly available computing resources, CASL's research aims for a step increase in the improvements in reactor operations that have occurred over the last several decades.

"CASL has been using modern high-performance computing platforms such as ORNL's Titan, working in concert with the INL Fission computer system, for modeling and simulation at significantly increased levels of detail," said CASL Chief Computational Scientist John Turner. "However, we also recognized the need to deliver a product that is suitable for industry-sized computing platforms."

With this recognition, CASL designed the Test Stand project to try out tools such as VERA-CS in industrial applications. CASL partner Westinghouse was selected as the host for the first trial run of the new VERA nuclear reactor core simulator (VERA-CS). Westinghouse chose a real-world application for VERA-CS: the reactor physics-analysis of the AP1000 PWR, which features a core design with several advanced features. Using VERA-CS to study the AP1000 provides information to further improve the characterization of advanced cores compared to traditional modeling approaches.

Westinghouse's test run on VERA-CS focused on modeling one aspect of reactor physics called "neutronics," which describes the behavior of neutrons in a reactor core. While neutronics is only one of VERA's capabilities, the results provided by VERA-CS for the AP1000 PWR enhance Westinghouse's confidence in their startup predictions and expand the validation of VERA by incorporating the latest trends in PWR core design and operational features.

"VERA-CS exhibited remarkable agreement with plant measurements as well as reference numerical solutions for startup cores, and for these reasons we decided to apply it, successfully, to the AP1000 start-up simulations," said Westinghouse Fellow Engineer Fausto Franceschini.

The CASL team now is working on extending the suite of simulation capabilities to the entire range of operating conditions for commercial reactors, including full-power operation with fuel depletion and fuel cycle reload.

Provided by Oak Ridge National Laboratory

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