New Nuclear Tools

IMPROVING NEXT-GENERATION REACTORS

BY SALVATORE SALAMONE

RENEWED INTEREST IN NUCLEAR energy has sparked new efforts to improve plant and reactor efficiency and safety.

Over the years while no new plants were under consideration, research efforts waned. But now, there is a sense of urgency to evaluate and incorporate new technologies that have sprung up over the last two to three decades into newer power plants.

Specifically, as part of a broad international trend to develop fourth-generation nuclear energy systems that could be deployed between 2020 and 2030, there is increased emphasis in two areas: improved computer models and simulations of nuclear plant operations, and incorporation of new materials into plant design.

For example, late last year the Department of Energy funded a $3-million research project to tap the processing power of two of the world's most powerful supercomputers to improve the safety and reliability of the next-generation nuclear power reactors.

The aim of the project is to develop a suite of tools that can be used to evaluate the operations of a sodium-cooled fast reactor, which is one of the more promising types of fourth-generation nuclear plants. In particular, researchers from a number of universities will create complex models of the various components of a nuclear energy system and run simulations to watch the reactor system perform as a whole or zoom in to focus on the interaction of individual components.

Because of the complexity, no one computer program can adequately simulate the entire reactor system. So researchers will use different computer codes for different components of the model and develop methods to link these components into a single, cohesive tool.

The researchers will use the simulations to study fuel performance, local core degradation, fuel particle transport, and several other aspects of the sodium-cooled fast reactors. By better understanding how design and operational issues will affect the reactor, "the new study will help to dramatically improve the design and safety of these reactors long before the first physical prototype is ever built," said Rensselaer School of Engineering professor Michael Podowski, the project director and principal investigator for this research.

COMPUTING MUSCLE A MUST

The suite of tools being developed to study the new reactors will require incredible amounts of computer processing power to run the sophisticated models and simulations envisioned. To meet the project's computational demands, the effort will use computers at the Brookhaven Computational Science Center and Rensselaer's Computational Center for Nanotechnology Innovations.

The computing power available at these facilities will enable researchers to develop the most sophisticated models to date and run simulations in faster times. The Brookhaven computer is ranked the 10th most powerful computer in the world with a maximum measured peak performance of 82 trillion floating point operations per second. The Rensselaer computer is ranked 12th with a peak performance of 73 TFLOPS.

To put that computing power into perspective, these systems each deliver about four to five orders of magnitude more computing power as compared with the most powerful systems that were available in the mid-1980s, which was about the time much of the research in this area was de-emphasized or put on hold after the accident at Chernobyl.

The sodium-cooled fast-reactor technology being investigated by Podowski and his team is increasingly getting more attention these days. In February, the Department of Energy, the French Atomic Energy Commission, and the Japan Atomic Energy Agency announced an expanded cooperation agreement to speed the development of sodium-cooled fast-reactor prototypes.

As part of a number of worldwide efforts to develop fourth-generation systems, organizations, researchers, and government agencies are focusing on several key technologies, of which sodium-cooled reactors are one. The other technologies being considered include the very-high-temperature gas reactors supercritical-water-cooled reactors, molten salt reactors and lead-cooled fast reactors.

Some of these reactors will operate at much higher temperatures than existing reactors. As such, to operate safely they will require new materials, such as a steel alternative based on carbon nano-fibers for containment walls. Modeling efforts will help, but the Department of Energy is also funding research into new materials. Here, again, the idea is to provide tools that will help engineers when making decisions about various components of a total system.

All of these efforts will play an important role in identifying the new technologies that should be incorporated into the next-generation nuclear reactors.

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