7 Research and Development of Fast Reactors

Enhancing the Ability of Research and Development

The fast reactor cycle (fast reactor and associated fuel cycle) is expected to supply enough energy to fulfill global electricity demands in a sustainable and environmentally friendly fashion. Fast-reactor technology allows the utilization of most of the available uranium resources, making it possible to continue operation for as long as a thousand years. By transmuting minor actinides, it significantly reduces the heat generation and radiotoxicity of vitrified radioactive waste that is to be disposed of geologically.

The “Fast Reactor Strategic Roadmap” put forth by the Japanese Government in December 2018 specified research target areas for the following ten years in fast reactor development in Japan. JAEA was requested to maintain fundamental research and development capabilities that meet the needs of the private sector, which will be proposing various innovative reactor concepts under the Nuclear Energy × Innovation Promotion (NEXIP) initiative, and to continue efforts toward the international standardization of safety and structural codes and standards, of which it has led development. Based on the research and development plan JAEA formulated commensurate with the Roadmap, JAEA’s Sector of Fast Reactor and Advanced Reactor Research and Development is developing numerical analysis tools and evaluation methods that fit with new reactor design concepts, the enhanced reduction of radioactive waste, and fuel cycle technologies such as fuel fabrication and reprocessing. Codes and standards for safety and structural design are being developed to best materialize the innovative characters of new reactors. The proposed codes and standards structure is summarized in Fig.7-1, where the safety standards and structural codes are seamlessly connected through risk-informed technologies and the System Based Code concept to allocate margins in a way that balances safety, economics, and sustainability most appropriately. JAEA is developing technologies to be equipped in the structure, and engages in standardization activities in international and overseas organizations as well as in Japan.

Some of the recent achievements in fast reactor developments at JAEA are described in this chapter. Efforts toward the commercialization of fast reactors, including recent developments in the feasibility of manufacturing the upper core structures of tank-type reactors using only domestic technologies, which were a result of a 3D-CAD-based design study conducted in collaboration with France, are reported in Topic 7-1. In Topics 7-2 and 7-3, the subject of thermal-hydraulic analysis is delved into. High-precision experimental data demonstrating the feasibility of the decay heat removal system for sodium cooled fast reactors is presented in Topic 7-2, whereas the feasibility of the fuel assembly with an internal duct to enhance the safety of sodium cooled fast reactors is detailed via a newly extended sub-channel analysis code is discussed in Topic 7-3. Moving to safety analysis developments in sodium-cooled fast reactors, the JAEA-developed oxide-dispersed strengthened steel used in the fuel cladding of sodium-cooled fast reactors was verified to have remarkable ultra-high temperature characteristics at 1000 °C, representing a significant improvement over conventional austenitic steels and thus offering improved core safety (Topic 7-4). Finally, the ignition of hydrogen gas was visualized in combustion tests using high-definition and high-speed shooting methods to clarify the fact that ignition of sodium mixed hydrogen jet is the ignition of hydrogen that occurs locally around ignited sodium mist, as discussed in Topic 7-5.

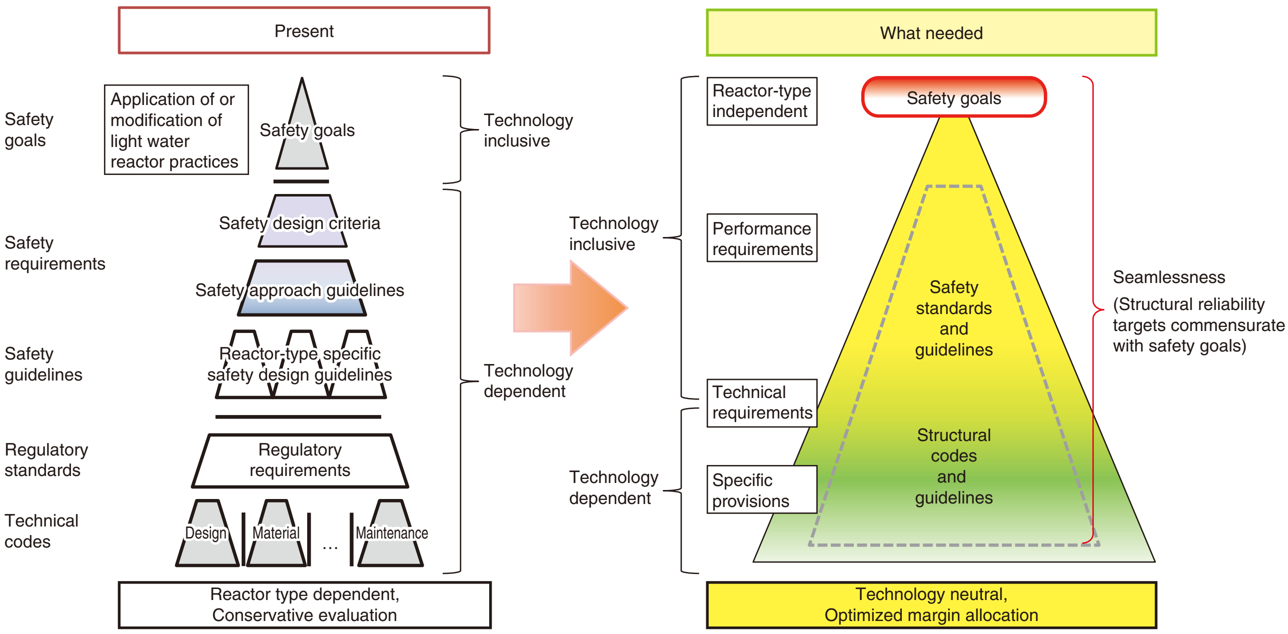

Fig.7-1 Structure of the codes and standards for nuclear innovation