Status and Roles of the Prototype Fast Breeder Reactor Monju

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The accident at the Fukushima-Daiichi nuclear power plants (NPPs) have enormously affected the operation and management of all the NPPs in Japan. Monju, Japan's prototype sodium-cooled fast breeder reactor, is no exception, even though the plant is still under the construction stage. Similarly to the other light water reactor plants, we have been asked to confirm the safety of the plant in an event of huge earthquake and tsunami, and against the potential severe accident progression following the natural disaster, and to consider safety measures to provide additional safety margins beyond the design basis.

Before going into further details, the history and present status of Monju is briefly explained. The safety review for construction permit was finished in 1983, followed by the plant construction and component manufacturing which then were completed in 1991. The initial criticality was attained in 1994 and the series of system start-up tests (SSTs) was initiated. In December 1995, when the SST was conducted at the 40% power level, a sodium leak accident took place at the secondary heat transport system, right outside the reactor containment vessel. The leaked sodium was non-radioactive and did not affect the safety (reactor shutdown and cooling) of the plant and resulted in no environmental consequence. Nevertheless the accident was treated very seriously by mass media and the majority of the general public thought Monju must be dangerous because sodium is dangerous. This was one of the major reasons why it had taken more than a decade before we could final bring the plant back to operation. We have modified the plant to reinforce the safety measures against sodium chemical reactions and obtained an approval from the regulatory authority and the local government. In May 2010, the first step of SSTs, zero-power core confirmation test, was initiated after the long reactor shutdown period for more than 14 years.

Up until the restart of Monju in 2010, a technology base to design and construct sodium-cooled fast reactors has been established in Japan based on the experience acquired through the experimental reactor Joyo and a comprehensive research and development program in the areas such as safety, fuel and material, components, thermo-hydraulics, instrumentation and control. The technologies have been further advanced even after the sodium leak accident with the activities: safety improvement against sodium leak and chemical reactions, back-check seismic safety evaluation, and other improvement in plant management system for operation and maintenance.

The major achievement of the first step of restarted SST, the zero-power core confirmation test, is highlighted by successful operation of the reactor and the cooling system without major troubles even after a long blank period with the reactor core containing americium-rich fuel. We have demonstrated safe control and operation of the reactor and heat-transport systems and confirmed the inherent negative reactivity feedback features. Although the core consisted of three different types of fuel subassemblies containing americium-rich 14-year-old fuel, we have shown that the criticality and other physics characteristics are accurately predicted.

Alter the completion of the core confirmation test in July 2010, we have conducted a series of preparation efforts for the second step of SST, namely 40% power plant confirmation test, which include the function testing of the balance of plant (a water and steam system and turbine). The Fukushima-Daiichi accident took place on March 11, 2011 during this process. Since soon after this severe accident, we have reviewed and reinforce, as far as appropriate, the safety of Monju taking full account of the accident progression in Fukushima and lessons learned, as requested by the regulatory authority and the local government similarly to the other NPPs in Japan. It must be noted Monju has advantageous (safe) features under a severe accident condition of station blackout and the resultant loss of heat sink. First the major plant facilities are placed on a ground level of 21m above the sea level and this is a significant advantage against tsunamis. Second the ultimate heat sink for decay heat removal in Monju is “air”. This is in contrast to light water reactors whose heat sink is sea water. Thus the cooling system in Monju does not depend much on the sea water system. In addition in the event of station blackout the decay heat from the core fuel can be transported through the sodium cooling system to the air cooler by “natural circulation”. This is a passive, and hence extremely reliable, safety feature of sodium-cooled reactor systems, and the effectiveness of natural circulation heat removal has been demonstrated by many reactor experiments conducted in the world.

Despite the Fukushima accident, we believe the roles of Monju as a prototype fast breeder reactor in Japan have not been changed. Based on Joyo experience, Monju is expected to demonstrate, in a larger scale, that the nuclear power generation is feasible and that the technology base has been made available. The data and experience in operation and maintenance of the plant are to be compiled and preserved for the design and operation of future plants. We believe it is extremely difficult to directly commercialize the fast reactor technology, without technology and knowledge base of Monju and its operation and maintenance experience.

The future plan of SSTs and operation of Monju will be judged based on a direction of the government-level discussions on framework of energy and nuclear policies which are to be established no sooner than summer of 2012. Before such decision is made we will keep our effort to improve the safety of Monju taking the lessons learned from Fukushima. We believe the risk level of Monju can be kept low and with added accident management measures to further improve safety the level will be made much lower.

Even though the Fukushima accident and its radiological consequence have severely discredited the nuclear energy systems in Japan, the situation of long-term needs for stable energy supply and global warming issue is unchanged. The fast reactor technology can provide a promising technology option to sustainably supply energy over centuries, and therefore the option shall not be abandoned, especially in countries like Japan having almost no domestic energy resources. The roles of Monju as a prototype therefore continue to be important. In addition, it must be emphasized that some of the international joint research programs using Monju are still actively continuing, because the reactor in one of the very few fast reactor plants that are operable today. Thus Monju is expected to play a role as an international asset to provide research facility and knowledge/technology transfer to future generations.