References of Super LWR and Super FR studies of the University of Tokyo and Waseda University at Oka-laboratory

February 24, 2019
Yoshiaki Oka, Emeritus professor of the University of Tokyo

   It includes calculational methods of core and fuel design, plant dynamics and control, plant startup and stability, safety and fast reactor design

   It includes experimental results of thermal hydraulics, materials, material coolant interactions as well as the single pass core design and the safety analysis of Super LWR and Super FR

3. Yoshiaki Oka, et. al., SCWR symposium papers from 2000-2013 held in Japan, Germany, Canada and China
   It includes the progress and summary of the studies at that time.
   3.2 Y.Oka et al., “Progress of Super Fast Reactor Phase 2 Project and Studies of Waseda University”, Proceedings of The 6th International Symposium on Supercritical Water-Cooled Reactors ISSCWR-6 March 03-07, 2013, Shenzhen, Guangdong, China , ISSCWR6-13035

4. Yoshiaki Oka, “Special lecture, Super LWR and Super FR R&D”, Joint ICTP-IAEA Course on Science and Technology of Supercritical Water-Cooled Reactors (SCWRs), International Center for Theoretical Physics, Trieste, Italy, 27 June to 1 July, 2011
   Presentation by power points

5 Jianhui Wu and Yoshiaki Oka, “Improved Single pass core design for high temperature Super LWR”, Nuclear Engineering and Design, 267(2014) 100-108
   Latest core design of Super LWR, Safety analysis of the reactor is found in the section 2.1.2.4 of the second book (ref.2)

Comments for the further studies and developments

Super LWR (thermal neutron spectrum reactor with UO2 fuel)

Several tens of test reactors of various kinds were constructed in USA and other countries in 1950s and 1960s (see for example, Robert Loftness, “Nuclear power plants” van Nostrand 1964), but SCWR is a new reactor which was not constructed/tested before. Large uncertainties existed when GIF started in the early 2000s. The uncertainties decreased through the conceptual design and fundamental experiments of thermal hydraulics and materials.

C1. Core internal structure of the two pass core was complex, but that of the single flow pass core is simple. It is good for refueling.

C2. Maximum cladding surface temperature criterion of 650°C for the core design looks adequate from the data which were obtained by out of pile corrosion experiment of the cladding material (improved austenitic SS cladding). In-pile loop testing of fuel and fuel rod bundles is the next step for the development, as was proposed in HPLWR program.

C3. Design goal of 500°C average outlet coolant temperature was set for using the conventional supercritical steam turbines without major modification. For the single pass core, it is reached by using thermally insulated water rods and using small fuel sub-assemblies in the periphery of the core. Thermal sleeve is equipped with the outlet coolant nozzles for mitigating the thermal stress. 

For lower outlet coolant temperature than 500°C, use of zirconium hydrides for moderation will be another option. The experience of zirconium hydrides of KNK in Germany will be useful for the study.

C4. Material coolant interactions is important subject for operation, but it needs to be studied with test reactors as was LWR.

Super fast reactor

Fast reactors need plutonium for the fuel. Priority of the developments is lower than
Super LWR which uses uranium fuel. Most R&D are common among Super LWR and Super FR. The experiments of thermal hydraulics, materials and material coolant interaction were carried out with the funding for the Super FR, but the results are useful for Super LWR. MEXT was in charge of fast reactor R&D in Japan, It is the reason why project of Super FR was proposed and funded.

Fast reactor does not need moderator and higher power density and smaller core than the thermal reactors. Super FR is a good subject for university researchers to pursue power cost reduction of fast reactors over thermal reactors, which is necessary for the commercialization. Breeding is research subject for the dream of the fast breeder reactors.

CF1. High breeding ratio will be not possible by using fuel assemblies by light water cooled reactors. Tube in shell type fuel assemblies increases fuel volume fraction and good for breeding, but it is exotic concept. Fracture of the welding of the coolant tubes to the shell by thermal cycling need to be prevented. Uranium resource will be not exhausted, because it increases with exploration and mining technology developments as other natural elements and resources.

CF2. Energy group structure of neutron cross section library at the resonance energy region should be subdivided for accurately calculating breeding ratio.

Yuki Honda, Sadao Uchikawa and Yoshiaki Oka, "Reconstruction of cell homogenized macroscopic, cross sections for analyzing fast and thermal coupled, cores using the SRAC system", Journal of Nuclear Science and Technology, 2014 Vol. 51, No. 5, 645-655

**Other notes**

For university research, the conceptual study of Super LWR and Super FR is good subjects for students and researchers to be familiar with the LWR design and analysis methods. Collaboration between reactor physics and thermal hydraulics researchers are necessary for computational method developments. For industry, it is a seed for the innovation and ventures for commercialization. For R&D institutes, it is a subject to conduct experiments with their facilities.

I did not study Super LWR and Super FR, since I left Waseda University in March 2014. I serve as the chairman of Japan Atomic Energy Commission from April 2014. I am not in the position of promoting particular reactor types as the chairman of JAEC. Restart of LWR is primarily important in Japan. I need to improve nuclear energy utilization and R&D in Japan. It is not technical ones.