Analyses of Fast Reactor Scenarios for Transmuting Transuranics in Korea

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Symbiotic fast reactor scenarios with the existing nuclear power systems have been analyzed from the viewpoint of a transuranics transmutation. In this study, a sodium-cooled fast reactor (SFR) and accelerator driven system (ADS) are considered as representative fast reactor systems. For a comparative analysis of the fuel cycle options, the once-through fuel cycle was at first analyzed based on the current nuclear power plant construction plan and operating nuclear power plants such as pressurized water reactor (PWR) and Canada deuterium uranium (CANDU) reactors. After setting up an once-through fuel cycle model, the SFR and ADS scenarios were modeled based on the same nuclear energy demand prediction used for the once-through fuel cycle. Then important fuel cycle parameters such as the amount of the spent fuel and corresponding plutonium, minor actinides and fission products inventories were estimated and compared with those of the once-through fuel cycle. In the fuel cycle model, the Pyro process is assumed for all the spent fuel recycling. In the process all the actinides are recovered and some fraction of the fission product is removed. The deployment fractions of the fast reactor are 25, 10 and 20% for the perios of 2030-2040, 2041-2070 and 2071-2100, respectively. In order to feed the fast reactor systems, it was also assumed that the PWR and CANDU spent fuel are reprocessed from 2025 and the fast reactor spent fuel reprocessing begins in 2035. The fuel cycle calculation was performed by the DYMOND code, which has been used for the analysis of the Generation-IV roadmap studies.

The analysis results of the once-through fuel cycle can be summarized as follows:
- The nuclear power demand is expected to grow to 25.2 GWe in the year 2100.
- The total spent fuel inventory is expected to be 65000 t in 2100.
- The transuranics and fission product inventories are estimated to be 660 and 2390 t, respectively, in 2100.

The fast reactor cycle analysis results can be summarized as follows:
- The SFR and ADS can transmute the transuranics by 56 and 130 t, respectively, which correspond to a reduction by 8 and 20% when compared to the once-through cycle.
- The total fission product inventories of the SFR and ADS cycle are 2800 and 2360 t, respectively, which are similar to that of the once-through cycle. For the long-lived fission products such as ^{129}I and ^{99}Tc, the SFR transmutes ^{129}I and ^{99}Tc by 0.8 and 3.2 t, respectively, while the ADS transmutes ^{129}I and ^{99}Tc by 4 and 16 t, respectively.

From the transmutation point of view, the ADS is better than the SFR. The transmutation rate is not high, which can be improved by increasing the deployed capacity of the fast reactor in the scenario. In future, it should consider the technical aspect and the large economic uncertainty in the ADS.