Spent Fuel Inventory Calculation for the Fast Reactor Cycle

Chang Joon Jeong and Hangbok Choi
Korea Atomic Energy Research Institute, P.O.Box105, Yuseong, Daejeon, Korea 305-600
cjjeong@kaeri.re.kr

1. Introduction

A full fissile plutonium and transuranic (TRU) recycle is achievable through a multiple recycle in fast neutron spectrum reactors, which extends the natural resource use and curtails the waste production. In Korea, the Korea Advanced Liquid Metal Reactor (KALIMER) [1,2] has been developed since 1992, which is a pool-type sodium-cooled fast reactor. The KALIMER was designed by two concepts: KALIMER-150 with a breeding ratio of 1.05 and 150 MWe and KALIMER-600 with a breeding ratio of 1.0 and 600 MWe.

In this study, a symbiotic fuel cycle between once-through power plant and KALIMER has been analyzed. Important fuel cycle parameters such as the amount of spent fuel (SF) and the corresponding plutonium, minor actinides (MA) and fission products (FP) inventories are investigated and compared with those of the once-through fuel cycle. Parametric calculations were performed by the DYMOND [3] code, which has been used for the analysis of the Gen-IV roadmap studies.

2. Calculation procedure

The fuel cycle calculations were performed under the assumption that the nuclear energy demand grows from 13.7 GWe in 2000 to 63.6 GWe in 2100 for all cases. In 2000, there were 12 pressurized water reactors (PWR) and 4 pressurized heavy water reactors (PHWR) in Korea, but there will be no more construction of the PHWR after 2000. For the KALIMER fuel cycle, it was assumed that the reprocessing begins in 2010 and the KALIMER is deployed in 2015. The electricity generation (or capacities) by the deployed KALIMER is 5%, 10% and 15% for the time periods of 2015-2035, 2036-2045 and 2046- 2100, respectively.

3. Results and discussion

Based on the once-through fuel cycle, the number of PWRs in 2100 is expected to be 47 with the reactor power of 1.4 GWe. The number of PHWR becomes 0 after 2040. For the SF inventory, it increases with time and the total SF will be 102.23 kt in 2100. Beyond 2049, the PHWR SF remains constant at 17.2 kt. The total amount of U and Pu in SF will be 95.59 kt and 1.23 kt, respectively. Also, the total amount of MA and FP in SF will be 0.13 kt and 5.28 kt, respectively.

Figure 1 shows the deployed reactor capacity of the KALIMER-150 scenario. The demand power is almost the same as that of the once-through fuel cycle. Beyond 2020, the PWR sharing of the electricity generation deceases, ultimately it goes down to ~80% in 2100. On the other hand, the remaining KALIMER-150 capacity increases to ~20% in 2100. Then the number of PWR and

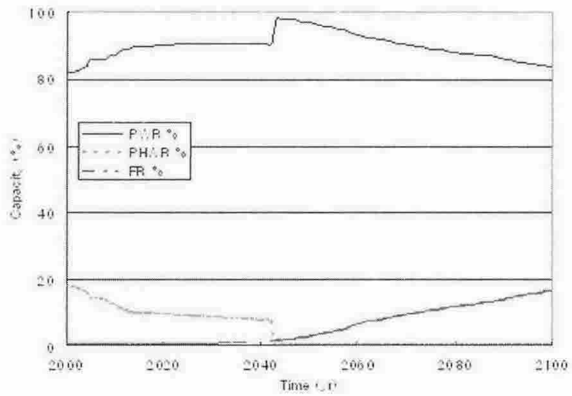

Fig.1 Reactor capacity variation for KALIMER-150 scenario

KALIMER-150 reactors increases and reaches 40 and 73, respectively, in 2100. According to the number of deployed reactors, the PWR SF decreases with time and becomes ~0 kt after 2065. The PHWR SF inventory is ~17 kt, which dominates the total SF inventory after 2065. The total amount of U, Pu, MA and FP are 88.49 kt, 0.70 kt, 0.12 kt and 5.16 kt, respectively.

The results for the KALIMER-600 scenario are given in Table 1 and compared with those of other scenarios. The trends of deploying the reactor are very similar to those of the KALIMER-150 scenario except for the number of reactors which is reduced by 1/4 when compared to the KALIMER-600 scenario because of the reactor capacity. The total amount of U, Pu, MA and FP are 88.68 kt, 0.87 kt, 0.11 kt and 5.16 kt, respectively.

Table 1 Comparison of the amount of SF (kt) and heavy element (kt)

	Once-through	KALIMER -150	KALIMER -600
PWR SF	85.03	0	0
PHWR SF	17.20	17.20	17.20
FR SF	0	0	0
Total SF	102.23	17.20	17.20
Pu	1.23	0.70	0.87
MA	0.13	0.12	0.11
FP	5.28	5.16	5.16
U	95.59	16.08	16.08
Recovered U	-	72.41	72.60

From the above results, it was found that the KALIMER scenario does not contribute to a reduction in the amount of MA and FP, which is important when designing a repository. For a further destruction of MA, an actinide burner can be considered in the fuel cycle.

ACKNOWLEDGEMENTS

This work has been carried out under the Nuclear Research and Development Program of the Korea ministry of science and Technology.

REFERENCES

[1] S. J. Kim et al., "Nuclear design and analysis report for KALIMER breakeven core conceptual design," KAERI/TR-2153/2002, KAERI, 2002.

[2] H. Song, S. J. Kim and Y. I. Kim, "Nuclear design of a Na cooled KALIMER-600 core with no blanket," *Advances in Nuclear Fuel Management III*, Hilton Head Island, SC, USA Oct. 5-8, 2003.

[3] US-Department of Energy, "A Technology Roadmap for Generation IV Nuclear Energy Systems," GIF-002-00, Dec. 2002.