The Design Features of the Double-Banked AMBIDEXTER Utilizing DUPIC FUEL

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1. Introduction

Since the on-site spent fuel storage capabilities at reactors in Korea are expected to be saturated in a few years, the government has been pressed to find a solution for the spent nuclear fuel. So far one of workable means for reducing the load would be utilizing *DUPIC* fuel cycle technology. The technology was developed through Korea-Canada-U.S. collaboration to utilize the LWR spent fuel for the CANDU reactor. However, by various sociopolitical reasons, the DUPIC technology has not been yet commercialized. As the other alternatives to use the DUPIC technology, Gen-IV reactors would be pertinent. In the following session, the design features of a molten salt reactor system that can burn DUPIC fuel are explained.

2. AMBIDEXTER-DUPIC System

2.1 General Design

The AMBIDEXTER[1] is an integral-type molten-salt reactor system. The AMBIDEXTER has been designed for the GEN IV requirements in terms of the sustainability, *the* safety and the proliferation resistance. $250MW_{th}$ AMBIDEXTER has been simulated by using the ORIGEN2-HELIOS-AMBIKIN2D code system [1, 2].

2.2. AMBIDEXTER-DUPIC system

Figure 1 shows the cut-views of the typical layout of the reactor system in the reactor vessel. Fluoride-salt fuel in liquid form flows upwardly through the circular channels in hexagonal graphite cylinder and gains fission heat. On-line feeding and reconditioning of the fuel salt stream is provided to maintain its desired composition. The ultimate objective for exercising this system concept is to design a closed fuel cycle, multiplex energy conversion, and regenerative radioactive waste management system [1,3].

DUPIC technology, recognized as a highly transparent method for reprocessing the PWR spent fuel, is used to produce AMBIDEXTER fuel materials. While the seed lattice zone of the reactor core dominantly functions of producing thermal power and surplus neutrons, the blanket lattice zone of it transmutes fertile actinides to fissile by neutron capture reactions. In addition, the blanket lattice zone has a fast neutron spectrum as shown in Fig. 2 which is similar as fast reactor so that burning of Pu is elevated. Among the fission products produced by fuel burn up, the noble gases are removed by separation from solvent, the noble metal group is removed by plating out on the surface of metal components, and several other nuclide groups are removed by high temperature chemical process and then, the reconditioned fuel salt is re-entering into core after the purification treatment.

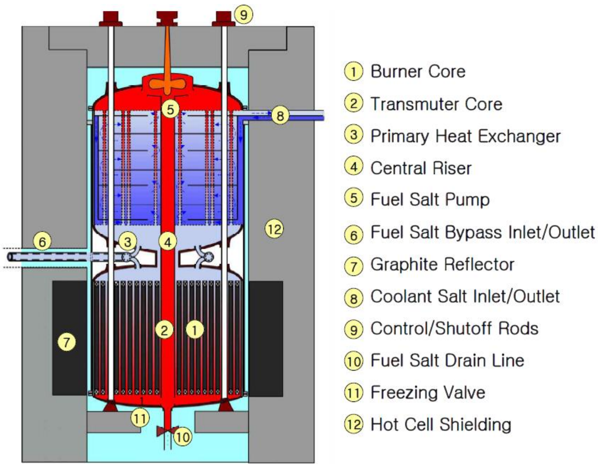

Fig. 1 AMBIDEXTER Integral Reactor System

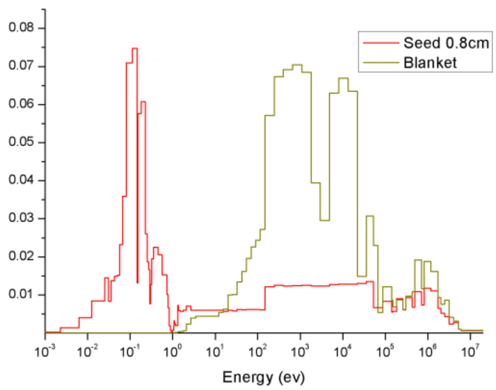

Fig. 2 Normalized Neutron Spectrum in Seed and Blanket lattice

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[1] Advanced Molten-salt Break-even Inherently-safe Dual-missioning EXperimental and TEst Reactor

As the AMBIDEXTER-DUPIC is a fluid-fuel reactor system and has two types of different lattices, such as the seed and the blanket, design analysis for fuel and physics with conventional depletion codes is limited.

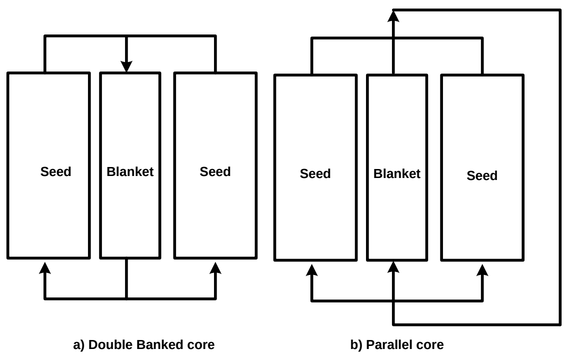

Fig. 3 AMBIDEXTER Core Configurations

Figure 3 shows two types of possible core AMBIDEXTER configurations. In the parallel core configuration, fuel stream split and flows into the seed and blanket core region. In this case, it is possible the fuel depleted in two separated different reactors and combined at the out flow. Therefore, the conventional fuel depletion code ORIGEN can be utilized. However, in the double banked core configuration, the seed and blanket lattice are correlated. The outflow composition of one lattice becomes the inflow of the other lattice so that the ORIGEN code cannot be used in the double banked core configuration. Therefore, AMDEC(A Computer code for Molten Salt Reactor to Calculate Nuclide DEcay and Creation) was developed to assess the radioactive nuclide depletion characteristics of advanced nuclear energy systems. In addition, validation tests required for a conceptual design code were executed.

The AMDEC is designed to simulate these nuclide generation, destruction, purification, and fuel flow processes so that it can calculate nuclide concentration change over time in different reactor components. By replacing the ORIGEN2 code by the AMDEC, the physics design code system for MSR-type reactors would improve its calculation accuracy.

The AMDEC uses a matrix exponential method to solve the coupled, non-linear first-order ordinary differential equation system, and is capable of analyzing physics performances of the double-banked AMBIDEXTER core, including the effects of the on-line reprocessing and on-line fuel feeding process. Besides, this code can simultaneously handle different library sets corresponding to the reactor and fuel types. A library set includes data of half-life, decay type, microscopic cross-section, and the fraction of (n,g), (n,2n), (n,3n), (n, α), (n,p), (n,f) and fission products.

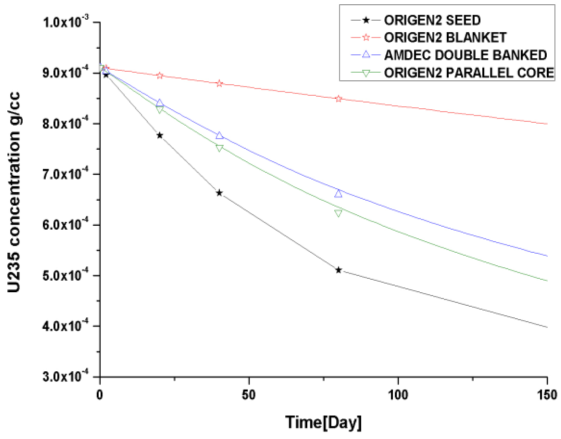

Fig. 4 Nuclide Concentration Change (U-235)

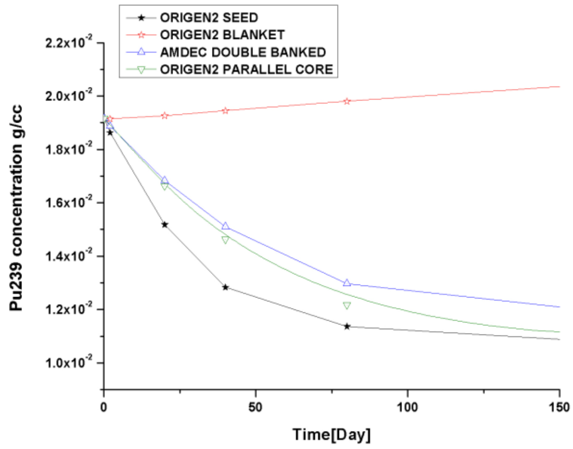

Fig. 5 Nuclide Concentration Change (Pu-239)

Figure 4 and 5 shows the fuel depletion calculation with ORIGEN2 and AMDEC. The figures shows between the serial and the parallel connections of the seed and blanket lattice zones, the serial would be more effective in burning up actinide more than 5%. In addition, the fuel breeding in blanket region is observed in Fig. 5.

3. Conclusions

The followings are derived as conclusions after considering all the factors; The AMDEC, compared to ORIGEN2 simulations, can calculate the nuclides concentration changes within 1% deviation in various core zones and reactor system components by using different library sets which are weighted with each neutron spectrum; Fuel-flow effects coupled with nuclear reactions is well reflected in the AMDEC

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