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Silicide Fueled Core for the KIJANG Research Reactor

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1. Introduction

Korea Atomic Energy Research Institute (KAERI) has been developing a new research reactor, which is named the KIJANG Research Reactor (KJRR). The KJRR is a medium flux reactor of 15 MW power and loaded with MTR (Materials Testing Reactor) type fuel assemblies. The KJRR adopts U-7Mo fuel of 8.0 gU/cm^3 as a reference fuel, but its fuel is not fully qualified yet. We have prepared a silicide fueled core for the KJRR as a fall backup option. This paper presents a nuclear analysis on the silicide fueled core.

2. U-Mo Core

The KJRR will be mainly utilized for isotope production, NTD (Neutron Transmutation Doping) production, and the related research activities.

2.1 Design Requirements

The design requirements were carefully prepared to fulfill its purpose. The requirements are as follows:

- Reactor power: ~20 MW
- Reactor type: pool type
- Max. thermal neutron flux: > 3.0x10^{14} n/cm^{2}s
- Operation day per year: ~ 300 days
- Reactor life: 50 years
- Fuel: LEU (Low Enriched Uranium) plate type fuel
- Reflector: Beryllium
- Coolant and flow direction in operation: H_2O, downward forced convection
- Reactor building: confinement

2.2 Core Configuration

The core configuration was optimized according to its purpose. The core is located within a core box, which will prevent core uncovered at any emergency state. The core design is strongly dependent on the number of in-core irradiation holes and CARs (Control Absorber Rods). A core model with 3 in-core irradiation sites fully surrounded with fuel assemblies was selected as shown in Fig. 1. This core is composed of 7x9 lattices with its active length of 60 cm. The nominal core consists of 22 fuel assemblies, in which 16 standard and 6 follower fuel assemblies are loaded.

A HTS (Hydraulic Transfer System) is located within the core box. Two PTS (Pheumatic Transfer System) and 5 NTD holes are located outside the core box. One hole is prepared for the FNI facility, which can be easily used for NTD. The outside of the core box is surrounded with Be, Graphite and Al, in which its materials are chosen depending on its accessibility and the fast flux level.

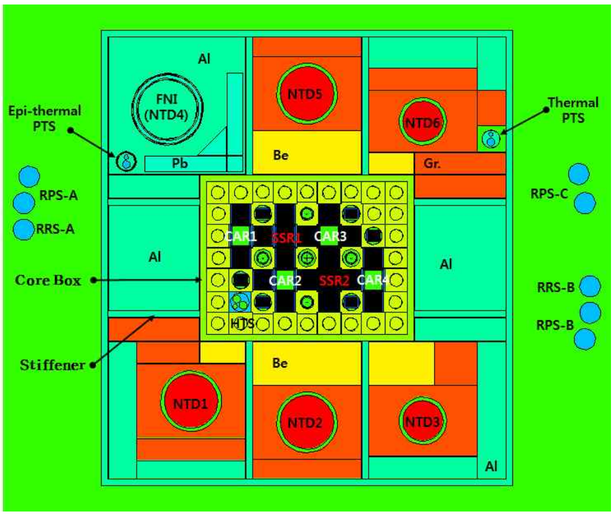

Fig. 1: Plan View of the KJRR Core

2.3 Current Core

The nuclear design of the KJRR satisfies all design requirements prepared. The KJRR core adopts U-7Mo fuel of 8.0 gU/cm^3 density for higher fuel economy. A high uranium loading gives us a long cycle length of 50 days. The total uranium loading of the nominal core is 70.1 kgU. Its major data are summarized as follows[1]:

- Fuel
  - U-7Mo: 8.0 gU/cm^3
- Fuel consumption per cycle: 2 FAs
- Cycle length: 50 days
- Maximum discharge burn-up
  - Assembly average: 67%U-235
  - Local peak: 86%U-235
- Reactivity Swing: 63 mk
- Shutdown margin: > 30 mk
- Max. thermal neutron flux
  - Core center: > 3.2x10^{14} n/cm^{2}s
- Max. power peaking factor: < 3.0
- Fission Mo production: > 2,000 Ci/week

3. Silicide Fueled Core

Fuel economy is very important to make the reactor competitive. The high density fuel is essential for higher fuel economy. As the U-7Mo fuel is not fully qualified, the KJRR core should be confirmed to be loaded with fully qualified fuel. The silicide fuel of U_3Si_2 4.8 gU/cc, which is being used at many reactors, is selected for this study. The total uranium loading of the silicide fueled core is 42.1 kgU. Lower uranium loading reduces its cycle length. When 2 fuel assemblies are loaded at every cycle, a cycle length of the silicide fueled core was estimated to be 25.5 days. Fig. 2 shows that cycle length is dependent on uranium loading.

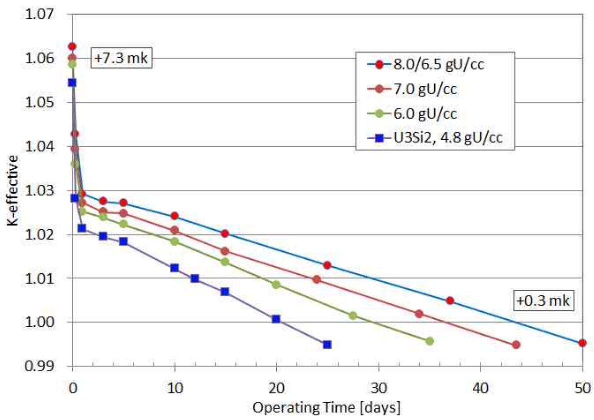

Fig. 2: Fuel Density and Cycle Length

The design requirement of cycle length is 37.5 days for the KJRR. For the silicide fueled core, three or four fuel assemblies are required to fulfill the minimum cycle length. It is found out that three fuel assemblies and 14.5 MW are proper for the silicide fueled core. Its reactivity swing is compared to that of the U-Mo core at Fig. 3. Its major data are summarized as follows:

- Fuel
  - U_3Si_2: 4.8 gU/cm^3
- Fuel consumption per cycle: 3 FAs
- Cycle length: 37.5 days at 14.5 MW
- Maximum discharge burn-up
  - Assembly average: 59%U-235
  - Local peak: 79%U-235
- Reactivity Swing: 65 mk
- Shutdown margin: > 40 mk
- Max. thermal neutron flux
  - Core center: > 3.5x10^{14} n/cm^{2}s
- Max. power peaking factor: < 3.0
- Fission Mo production: > 2,000 Ci/week

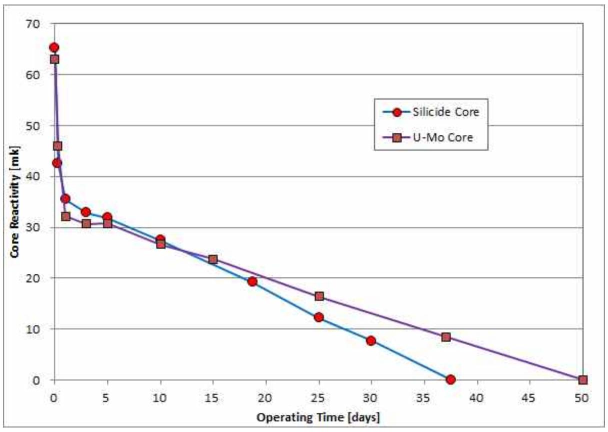

Fig. 2: Comparison of Reactivity Swing

In the silicide fueled core, maximum thermal flux is slightly increased, but cycle length is very short compared to the U-Mo core.

4. Conclusions

We succeeded in obtaining a fall backup option for the KJRR. It is found out that the current core can accommodate silicide fuel without severe modification. The silicide fueled core doubles its fuel consumption compared to the U-7Mo core.

REFERENCES

[1] Chul Gyo Seo, et al., "Conceptual Nuclear Design of the KIJANG Research Reactor," European Research Reactor Conference 2013, St. Petersburg, Russia, 2013.