Transient analysis of a reactivity insertion accident induced by irradiation target mishandling in the KJRR

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1. Introduction

The Ki-Jang Research Reactor (KJRR) is a research reactor under construction in Ki-Jang. In the KJRR, irradiation targets can be loaded or unloaded during power operation to produce radioisotopes. If an irradiation target is improperly manipulated (mishandled), it can induce a positive reactivity change in the core. In this study, a reactivity insertion accident induced by irradiation target mishandling was simulated and analyzed.

2. Methods and Results

2.1 Calculation model and method

The transient calculations of reactivity insertion accident were performed using RELAP5/MOD3.3[1]. Figure 1 shows the calculation model for the KJRR. The model is composed of reactor, primary cooling system (PCS), safety residual heat removal system (SRHRS) and reactor pool[2].

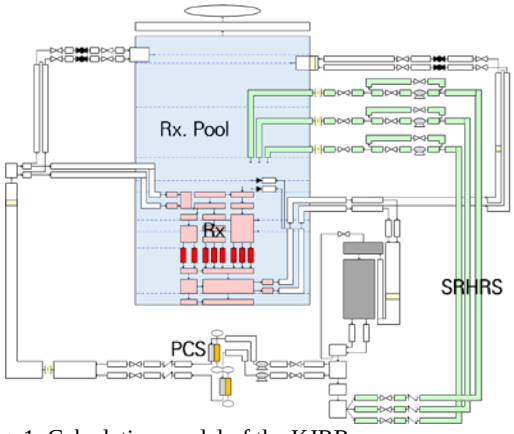

Fig. 1. Calculation model of the KJRR

2.2 Calculation results

The initial conditions were conservatively assumed based on the acceptance criteria. Reactor trip was conservatively assumed to be initiated by the second reactor trip signal. Reactivity from irradiation target was considered in the range of 0.5 to 1.5 mk in the calculations.

Figure 2 and Figure 3 show the Minimum Critical Heat Flux Ratio (MCHFR) and maximum fuel centerline temperature from calculation results. The MCHFR decreases at low durations, whereas it increases at high durations. The fuel temperature shows an inverse trend to the MCHFR. The point of inflection occurs because the reactor trip signal is different according to the reactivity insertion rate. The second reactor trip assumption introduces greater changes to the reactor trip signal based on the reactivity insertion rate, which in turn makes the trends of MCHFR and fuel temperature more complex. This trend becomes less pronounced as the amount of reactivity decreases.

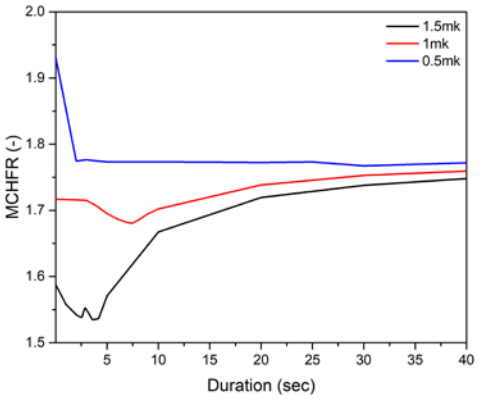

Fig. 2. MCHFR trend depending on the reactivity insertion rate

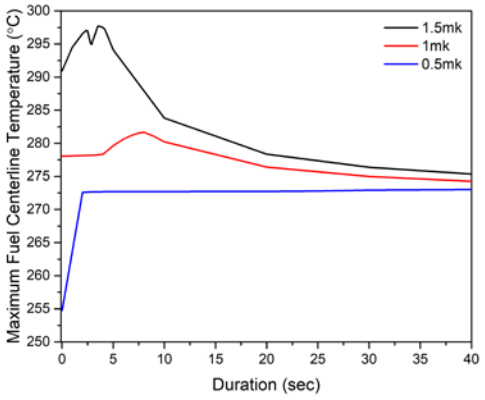

Fig. 3. Fuel temperature trend depending on the reactivity insertion rate

The most limiting case is observed under the highest reactivity condition, which is 1.5 mk. A specific reactivity insertion duration yields more limiting results compared to a step insertion.

3. Conclusions

The reactivity insertion accident induced by irradiatio n target handling is a research reactor specific-event. In this study, a sensitivity analysis was performed on both the irradiation target reactivity and the reactivity inserti on duration. The case of a 1.5 mk reactivity insertion ov er a few seconds was confirmed to yield the most limiti ng results.

ACKNOWELGEMENTS

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REFERENCES

[1] RELAP5/Mod3.3, Code Manual Volume V, User's Guideline, NUREG/CR-5535/Rev1, 2001
[2] Donghyun Kim and Jong-Pil Park, Transient analysis of a reactivity insertion accident induced by the withdrawal of a single control rod in the KJRR, KNS, May, 2025.