Sensitivity analysis for a reactivity insertion accident in the conceptual design of a critical assembly

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1. Introduction

A critical assembly is a reactor designed to conduct various experiments for research and educational purposes operating at zero power level[1]. This facility should be designed with only the minimum components necessary for safety to be a simple and cost-efficient facility. Simultaneously, it is required to maintain a high level of safety and mitigate transients with inherent safety of the reactor.

In this study, a sensitivity analysis of reactivity insertion accidents was performed for the conceptual design of the critical assembly using MARS-KS code. Through the analysis results, we confirm the importance of design parameters such as kinetic parameters, and utilize these findings to estimate acceptable levels of excess reactivity

2. Analysis method and Results

2.1 Calculation model and initial conditions

Figure 1 shows the calculation model for the conceptual design of the critical assembly. The model is composed of core, inlet plenum, grid plate, support plates and pool. The initial conditions are assumed to be 10 W of reactor power and 25 ℃ of coolant temperature.

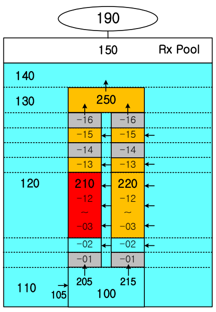

Fig. 1. Calculation model for conceptual design of critical assembly

2.2 Results of sensitivity analysis

Figure 2 shows the analysis results of the maximum fuel temperature according to the reactivity insertion amount for step insertion and ramp insertion of reactivity. The results for ramp insertion and step insertion are nearly identical. As the inserted reactivity should be compensated by the feedback effect due to the increase in fuel temperature, the maximum fuel temperatures are shown to be consistent. Assuming conservative conditions for design parameters such as temperature coefficients, it is easily acceptable to postulate a reactivity accident of 3mk insertion in the conceptual design phase.

Figure 3 shows the effects of the fuel temperature coefficient on maximum fuel centerline temperature, while figure 4 shows the effects of the coolant temperature coefficient on maximum fuel centerline temperature. It is obvious that a higher temperature coefficient decreases the maximum fuel temperature in a reactivity accident. Since the fuel temperature coefficient is more effective in reducing fuel temperature compared to the coolant temperature coefficient, having a high fuel temperature coefficient is crucial for the safety margin in the critical assembly.

In figure 5, it shows the effects of the coolant volume in the pool on maximum fuel centerline temperature. The heat from the core in the critical assembly should be removed through natural circulation of the pool water, coolant temperature rising speed is inversely proportional to the volume of the pool. It can be observed that there is a difference of about 20 degrees depending on the coolant volume.

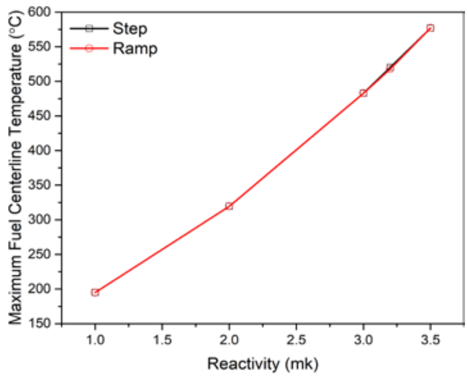

Fig. 2. Effects of reactivity inserted for ramp and step insertions on maximum fuel temperature.

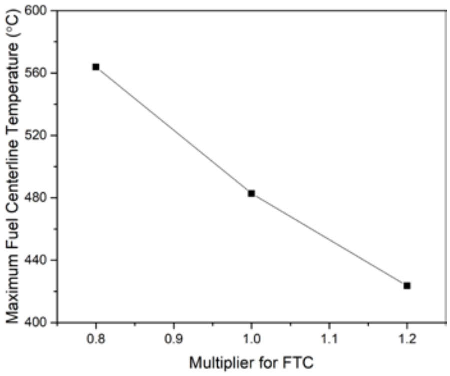

Fig. 3. Effects of fuel temperature coefficient (FTC) on maximum fuel centerline temperature.

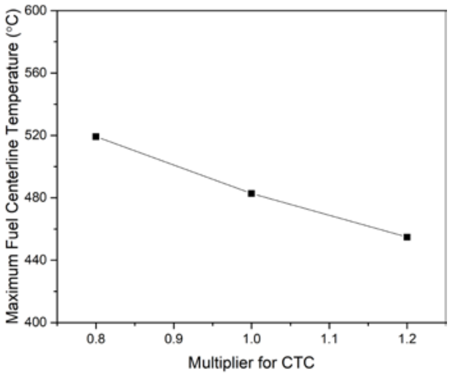

Fig. 4. Effects of coolant temperature coefficient (CTC) on maximum fuel centerline temperature.

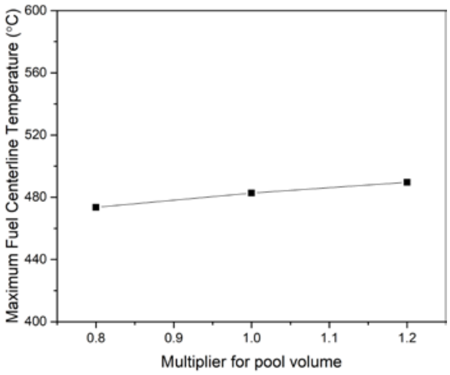

Fig. 5. Effects of coolant volume in pool on maximum fuel centerline temperature.

3. Conclusions

Through the sensitivity analysis for a reactivity insertion accident, the effects of design parameters on maximum fuel centerline temperature are confirmed. The analysis results will be utilized for the design of the critical assembly.

ACKNOWELGEMENTS

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