Evaluation of Core Average Temperature Using RELAP5

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1. Introduction

This study focuses on the accurate evaluation of the power coefficient, an important indicator in core design. The power coefficient is used to assess reactivity by applying temperature changes due to thermal power variations. Given that the core of research reactors can have asymmetric shapes depending on various operational purposes, the precision in evaluating the core average temperature becomes even more crucial. The objective of this research is to develop a methodology for precisely evaluating the core average temperature based on thermal power and integrating this assessment into the power coefficient analysis.

2. Methodology

The use of RELAP5 facilitates a better regulatory response compared to CFD analysis; thus, this study employs RELAP5 to calculate the temperature of structural areas within the core. Figure 1 visually represents the core configuration of the Kijang research reactor [1].

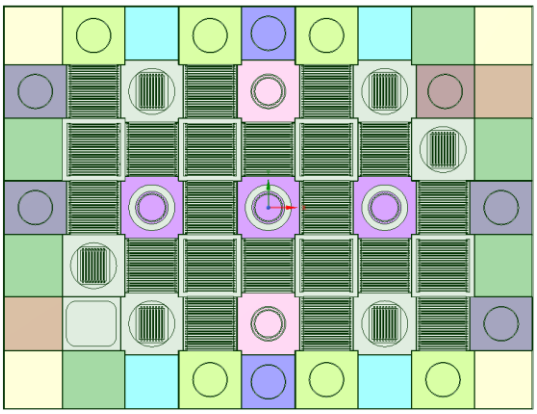

Fig. 1. Visual Representation of the Kijang Research Reactor Core Configuration.

Considering basic inputs, including the presence of an oxide layer for each core component, temperatures across different regions (fuel meat, fuel coolant channel, non fuel coolant channel, Be reflector, structure) were calculated. The methodology consists of the following steps:

1. Extracting thermal power under normal operation conditions from the MCNP tally file [2],
2. Generating inputs based on given inlet temperatures and thermal powers,
3. Performing RELAP5 analysis for each input file,
4. Calculating the average temperature of each core area from RELAP5 result files,
5. Evaluating the linearity of the core average temperature with respect to thermal power.

This calculation process was conducted using Excel macro and Python program, and Figure 2 provides the flowchart of this methodology. A total of 1,820 calculations were performed according to the conditions listed in Table I, assessing the variation in average temperature under different inlet temperature/thermal power conditions.

Table I: Conditions for the Evaluation of Core Average Temperature: Inlet Temperature/Thermal Power Scenarios

Variable	Conditions
Number of Core Components	26
Inlet temperature	3°C to 35°C, in 5°C increments
Thermal power	10% to 100% in 10% increments

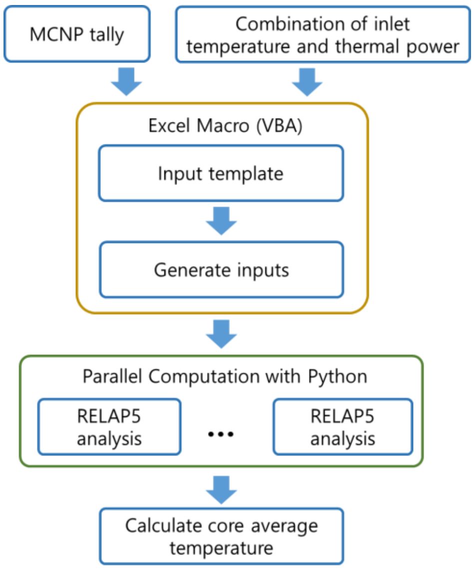

Fig. 2. Flowchart of the Methodology for Evaluating Core Average Temperature Using RELAP5.

3. Results

The analysis has been refined to evaluate the partial derivative values of core average temperature, offering a deeper insight into the reactor's thermal behavior. Figure 3 demonstrates how the core average temperature's sensitivity to thermal power varies at a constant inlet temperature of 35°C, indicating non-linear characteristics. Conversely, Figure 4 demonstrates the temperature's sensitivity to varying inlet temperatures at a fixed thermal power of 100%. The analysis confirmed that the temperature change is not constant, implying that the linearity of the core average temperature may not be guaranteed depending on the thermal power.

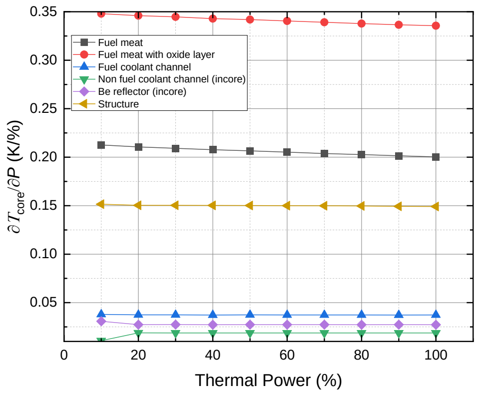

Fig. 3. Partial Derivative Values of Core Average Temperature with Thermal Power at an Inlet Temperature of 35°C.

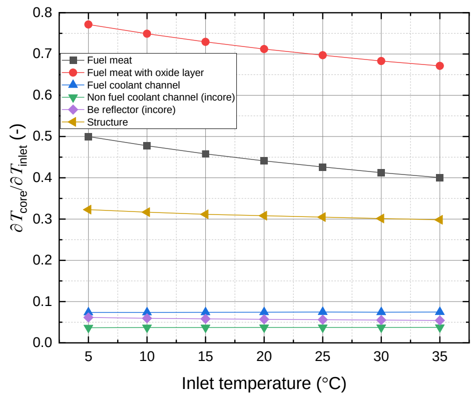

Fig. 4. Partial Derivative Values of Core Average Temperature with Inlet Temperature at 100% Thermal Power Condition.

4. Discussion and Conclusion

This research highlights the significance of accurately evaluating and incorporating the average temperature of each area for cores with asymmetric shapes, such as those in research reactors, into the power coefficient. The utilization of RELAP5 allows for effective modeling of complex core components, including the consideration of an oxide layer. The methodology and findings of this study are anticipated to significantly contribute to core design and safety assessment, underscoring the potential for future work in this area to further refine and apply these evaluation techniques.

ACKNOWLEDGEMENT

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