Development of a 3D Nuclear Reactor Core Design System for iSMR

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1. Introduction

The innovative Small Modular Reactor (iSMR) is gaining interest as next-generation nuclear power technology in domestic reactor research, with design and research underway. In order to optimize reactor core design, it is important to reduce designer errors in the design process and deliver information to the designer.

In this study, an application was developed that provides a user-friendly interface for editing and visualizing input and output data nuclear core design codes. The application allows core designers to use design codes efficiently with minimal designer mistake.

In the future, a function that supports assessing the load-follow operation performance – the main iSMR design requirement – will be put into use [1]. It is crucial for this support function to rapidly view and display the results of calculations in real time. This study confirms that it is possible to implement real-time load-follow operation tracing by evaluating the visualization module's performance.

2. System Application

A 3D nuclear reactor core design application called iSMR Optimizer, which is compatible with the Windows OS, was developed for this project. This section describes a few of the application's features, including the input designer and output viewer.

2.1 Input Designer

Domestic nuclear core design codes like ASTRA [2] and MASTER [3] do simulation calculations by setting up a number of input data sources. The text file format used as the input data for these design codes requires direct editing by the core designers in accordance with the standard. However, directly updating a text-formatted file without the use of any tools is inconvenient and inefficient. Additionally, an inaccurate computation may be made if there is an input error during the data entry process. Specifically, in addition to convenience, it is necessary to have a function to preview the complete layout when altering a fuel loading pattern layout or control rod position layout that is composed of array.

iSMR Optimizer allows input data editors of design code as user interfaces, with a focus on layout editor features. Designers can place nuclear fuel assemblies to a layout with a simple mouse click, and they can see how the total layout by just editing one of the quadrants. The loading pattern layout screen of the iSMR Optimizer is shown in Fig. 1.

This application can convert input form contents to design code input data, which designers can then perform design code processes.

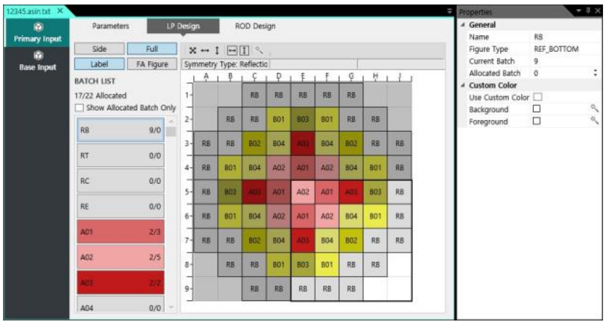

Fig. 1. The loading pattern layout screen in input data editor of iSMR Optimizer.

2.2 Result Viewer

The result data from design code is divided into two categories: summary and detailed. The summary data summarize and provide each fuel assembly's power or burn-up value; however, fuel assemblies have varied value data depending on operation time and axial position of each fuel rod. The values are kept in big text files, which makes it difficult to analyze and plot the results.

iSMR Optimizer not only displays summary power or burn-up results for the loading pattern model, but it also displays power or burn-up results for individual fuel rods in fuel assemblies based on operation time and axial position.

3. Visualization of Rod Layout in Result Viewer

The iSMR Optimizer may display a visualization screen of fuel assembly layout data such as batch type, power, burn-up, and control rod position based on design code results. Like the input designer, the result viewer can display a rod layout screen by switching between the overall layout and one of the quadrant layouts. Figure 2 shows the fuel assembly layout visualization function.

When a single item in the fuel assembly layout is selected, a separate screen displaying the total fuel rod layout may be viewed. The moving position control slider displays the power or burn-up value of each fuel rod at a certain axial position.

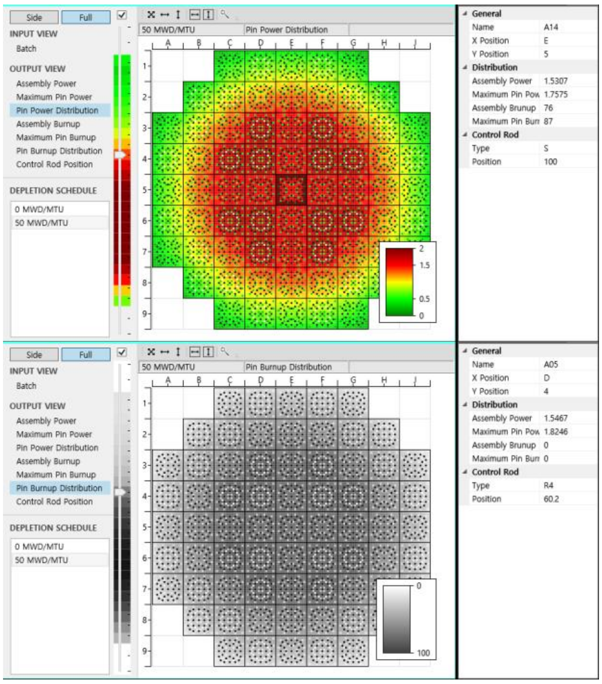

Fig. 2. The output view screens in result viewer for fuel assembly power and burn-up distribution.

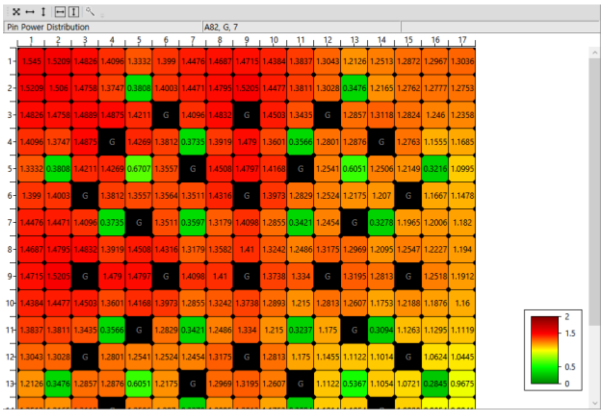

Fig. 3. The pin power distribution of result viewer in a single fuel assembly.

4. Conclusions

The iSMR Optimizer's visualization module makes it simple to determine the location of the maximum power point in the fuel assembly or fuel rod.

It is important to visualize and print the results in real-time for the load follow support module, which is one of the main application modules to be added to the iSMR Optimizer in the future. Through testing the result viewer module, it was confirmed that there is no visual performance issue. It is expected that this application can contribute to load follow performance evaluation for the iSMR.

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