

INTERACTIVE NUCLEAR DESIGN ANALYSIS PROCESS AUTOMATION ON WORLD WIDE WEB

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ABSTRACT

The nuclear reload design analysis requires time-consuming and erroneous model-input preparation, code run, output analysis and quality assurance process. To reduce human effort and increase overall model quality an interactive and automated design process based on World Wide Web (WWW) was designed. Using the proper mix-up of server-side and client-side programs like Common Gateway Interface (CGI) programs and JavaScript, the design process on WWW is modeled as a design wizard style so that even a novice designer can produce design products without error. That is, when a designer interactively inputs a simple basic data required in a reload design analysis via a web browser on PC, error-free model input preparation, code run and subsequent output processing are performed automatically. This interactive automation process on WWW is now implemented for time-consuming safety analysis at the KEPCO Nuclear Fuel Company (KNFC) reload design process for ABB-CE type PWRs. The application of this process shows a lot of time and effort reductions in the nuclear design analysis. Consequently, it is confirmed that the state-of-the-art WWW application to the nuclear design analysis can simplify the user interactions and reduce non-value added activities to decrease overall process time and to provide a framework for the entire ABB-CE type PWRs reload design process.

1. INTRODUCTION

Modern nuclear reload design analysis requires the use of sophisticated and complex three-dimensional core nodal models and several computer codes. Much time and effort is spent on preparing accurate model inputs, code run and output processing. This design process employs detailed model-input preparation and quality assurance, code run, and output analysis and re-quality assurance process.

KNFC has been performing both ABB-CE and Westinghouse nuclear design analysis, based on the each nuclear design code system and methodology. Recently we have been re-examining and re-engineering ABB-CE nuclear design analysis processes from a different perspective, mainly high quality of design model as well as design productivity perspective. The nuclear input model

preparation process has been re-engineered to reduce the process time and increase the overall model quality. The re-engineered process involved process mapping and the identification of steps, which could be eliminated and/or simplified. The recent re-engineered process covers the following design area;

- Physics input to FMD/FATES/TORC/Fr vs. Power/LOCA
- Design Parameter
- Physics Data for SLB/ASGT/COLSS/CPC
- Full Core Load Map

The above mentioned design process is characterized by its straight forwardness. In other words, after the designer prepares design inputs, the design products are produced by the predetermined procedures as shown in the Figure 1. Therefore no user interface or simple character user interface is enough to automate this simple one-step design process.

Such design processes, however, as a loading pattern search, single Control Element Assembly (CEA) withdrawal accident analysis, and etc. are much complex, multi-stepped, interactive with designer's response and inter-linked with other analysis results. For example, in the single CEA withdrawal accident analysis, taking into account the CEA ejection accident analysis results, some preliminary calculations are required to reduce the number of calculation cases. Based on the preliminary calculation results and engineering judgments the main calculations are made (See Figure 2).

To automate and facilitate this interactive and multi-step calculations the graphic user interface (GUI) is very useful. X Window system on the engineering workstation is the most conventional and widely used GUI. C++ with Motif toolkit is popular for this purpose. However, since the computing environment is so rapidly changing that software made today may be outdated easily, the cross-platform or platform-independent software is highly recommended. The distributed computing to share the resources on the network is another must to be considered. Therefore, a new paradigm to meet this claim is needed.

2. WORLD WIDE WEB AS A DESIGN TOOL

World Wide Web (WWW) ¹ was used for interactive nuclear design automation process tool due to its following merits.

- [1] Openness – Any hardware with any software is possible on Internet.
- [2] Easy of use – Using a web browser is easy to use for designer while programming on a web browser is easy for developer since the web browser itself is a good GUI environment.
- [3] Low cost – An expensive engineering workstation can be replaced with a web browser installed PC.
- [4] Flexibility – Every solution can be provided if needed.
- [5] Scalability – WWW can be not only connected easily with the design and operation database, but also expanded easily to the support of power plant operation.
- [6] Innovation – WWW is still under the development and new innovative technology can be applied continuously.

The interactive and automated design on the WWW (WWW design for short) is based on the client-server architecture, which is illustrated in Figure 3. A designer accesses the WWW using a browser client, typically on a desktop machine such as a PC, Macintosh or Unix Workstation. The client will display hypertext links in some manner, such as underlining the links. Selecting a link by clicking a mouse button to send a request over the network (strictly speaking, local Intranet). The request is sent to a WWW server, which typically runs on a powerful computer system. The server will retrieve the

file, which has been requested, deliver it to the client and communicate with the engineering workstation for the design calculation.

Using the proper mix-up of server-side and client-side programs like Common Gateway Interface (CGI) ² programs and JavaScript ³ as shown in Table I, the WWW design is modeled as a design wizard style. Following the design wizard, even a novice designer can produce design products easily while keeping the quality assurance standard and eliminating any possibility of erroneous inputs. That is, when a designer interactively inputs a simple basic data required in a reload design analysis via a web browser on PC, error-free model input preparation, code run and subsequent output processing are performed automatically. This WWW design was successfully implemented for some time-consuming safety analysis in the KNFC reload design of ABB-CE type PWRs including Yonggwang Unit 3, Cycle 5 and Yonggwang Unit 4, Cycle 5. A few examples are given below.

3. APPLICATION EXAMPLES

3.1 SINGLE CEA WITHDRAWAL ACCIDENT ANALYSIS

The single CEA withdrawal within deadband is an Anticipated Operational Occurrence (AOO) postulated to occur when equipment malfunction or operator error initiates a withdrawal of a single CEA or CEA subgroup from its initial allowed position. The detailed design procedure is too complex to describe here, and the brief procedure is illustrated in Figure 4. In order for a designer to make design products under the traditional design process, he/she should spend time and effort in collecting prerequisite design data, making more than two-decade code inputs for scoping calculations, analyzing code outputs and then making about three-decade inputs for main calculations. While it takes a few days under the traditional design process, a few hours are enough if WWW design is used.

The WWW design begins with the input to common design database as illustrated in Figure 5. This design database is divided into two categories; the plant-specific database and the cycle-specific database depending on the variables. These design databases are used in the subsequent reload design analyses. The first step of single CEA withdrawal accident analysis is the scoping calculation, which is the determination of the most conservative analysis point to reduce the calculation cases. The designer can make scoping calculation input by filling out the blanks and selecting the menu as shown in the Figure 6. Next, the web server generates an error-free input and requests the designer to send the input to the engineering workstation to calculate as shown in Figure 7.

Any error or deviation from the design procedure is impossible during the WWW design because the program does not allow the designer to go to the next step and shows the proper directions by popping up the dialog box if designer makes a mistake (See Figure 8). The inputs are sent to the workstation and the nodal code calculations are made automatically. Repeating the same procedure makes more scoping calculation and the whole output summary is made. Based on the scoping calculation results, the main calculation and subsequent post-processing is made. Figure 9 shows the final output summary and the designer can make documentation easily by merging this summary into an MS Word template file.

3.2 CEA DROP ACCIDENT ANALYSIS

In case of CEA drop accident analysis, the WWW design produces about 100 to 200 case model inputs

and output processing within a few hours, while traditional nuclear design process requires a few days to produce the same inputs and outputs as the case. The basic design approach of CEA drop accident on WWW is the same as that of single CEA withdrawal accident. Figure 10 shows the first page of CEA drop accident analysis on WWW.

3.3 OTHER APPLICATION AREAS

CEA Withdrawal Accident analysis is the next item to be automated with this WWW tool. This design automation is now under the development. Eventually all the other design items will be automated under the WWW. The design items automated earlier by conventional Fortran language can be remodeled easily taking after single CEA withdrawal accident. The GUI interface to loading pattern search can be programmed by Java applet, which is good tool for more interactive and higher quality graphics.

The WWW design can also be extended to such power plant support area as on-line nuclear design report, plant operation data analysis. In other words personnel in power plant can receive better operation support by reading nuclear design data on WWW without time lag and by receiving operation data analyzed by the designer.

CONCLUSIONS

The interactive automation process using WWW is now being successfully implemented for some time-consuming safety analysis process in the KNFC reload design of ABB-CE type PWRs. The application of this process shows a lot of time and effort reductions in the nuclear design analysis. Also, the interface, using a graphical user interface (GUI) windowing system, provides a uniform method for entering physical data and producing model inputs without human intervention, which improves the quality of the overall design effort. Consequently, it is confirmed that the state-of-the-art WWW application to the nuclear design analysis can simplify the user interactions and reduce non-value added activities to decrease overall process time and to provide a framework for the entire ABB-CE type PWRs reload design process.

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Table I. Development Environments

	Server-Side Programming	Client-Side Programming
OS	HP-UX 10.20	Windows 95/NT or HP-UX 10.20
Engine Program	Web Server (Apache 1.30 ⁴)	Web Browser (MSIE ⁵ , NC ⁶)
Languages	Perl ⁷ , Tcl/Tk ⁸ , Shell Script, C/C++, Fortran, etc.	HTML ⁹ , JavaScript, Java ¹⁰ , etc.

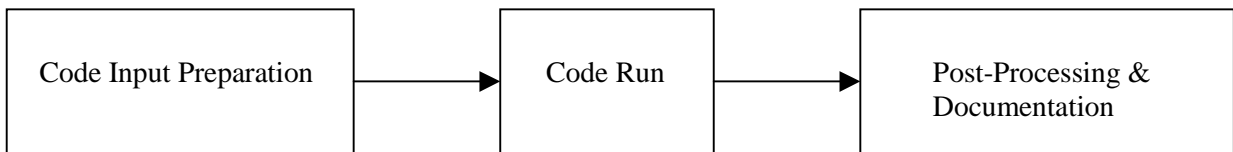


Figure 1. Simple and Straight-Forward Design Procedure

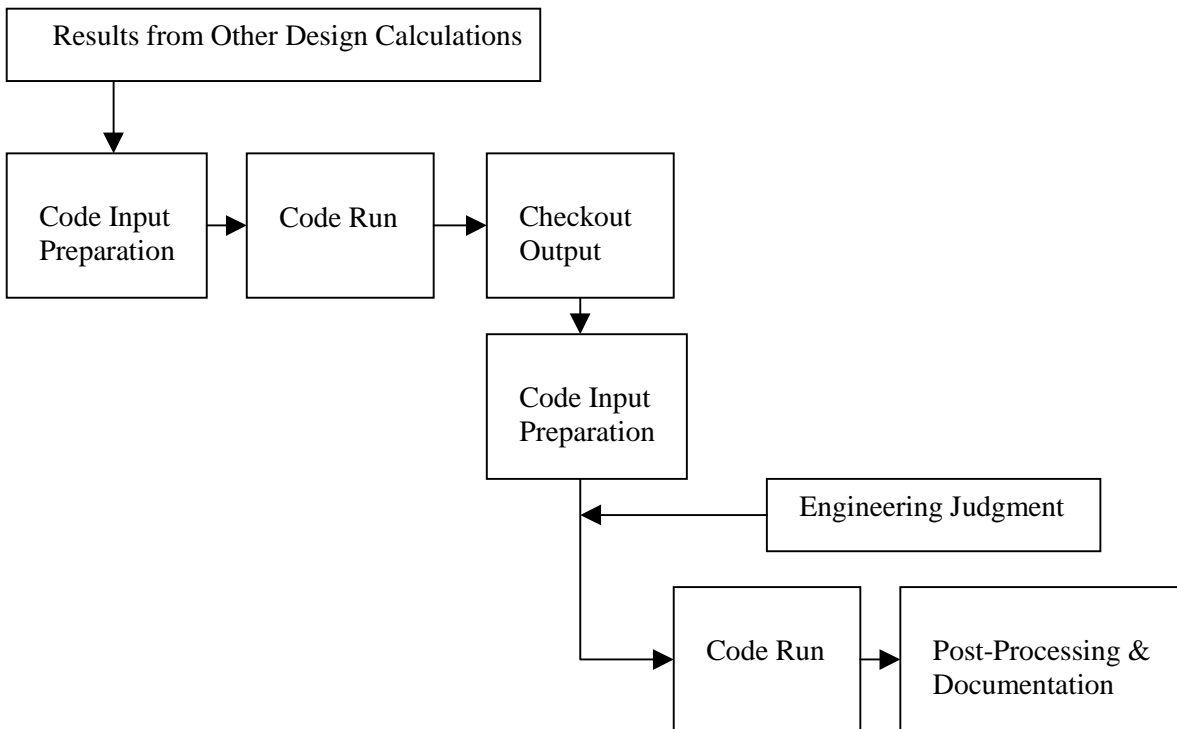


Figure 2. Complex and Interactive Design Procedure

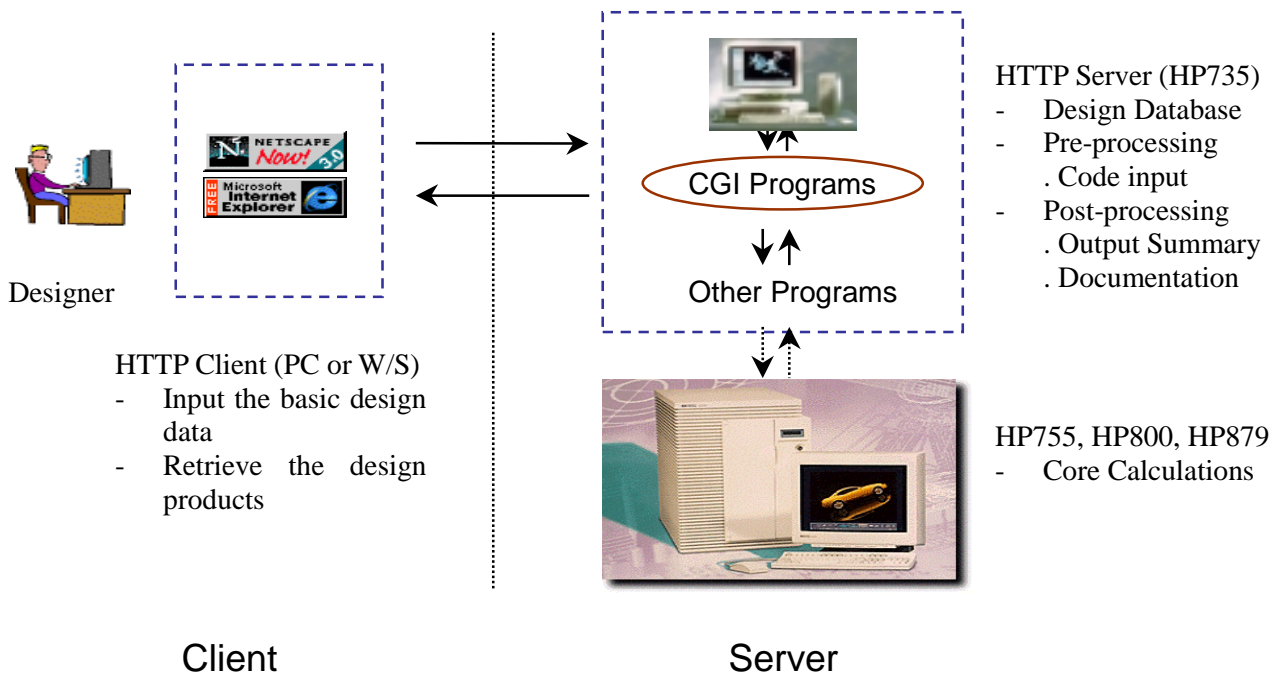


Figure 3. Client-Server Architecture

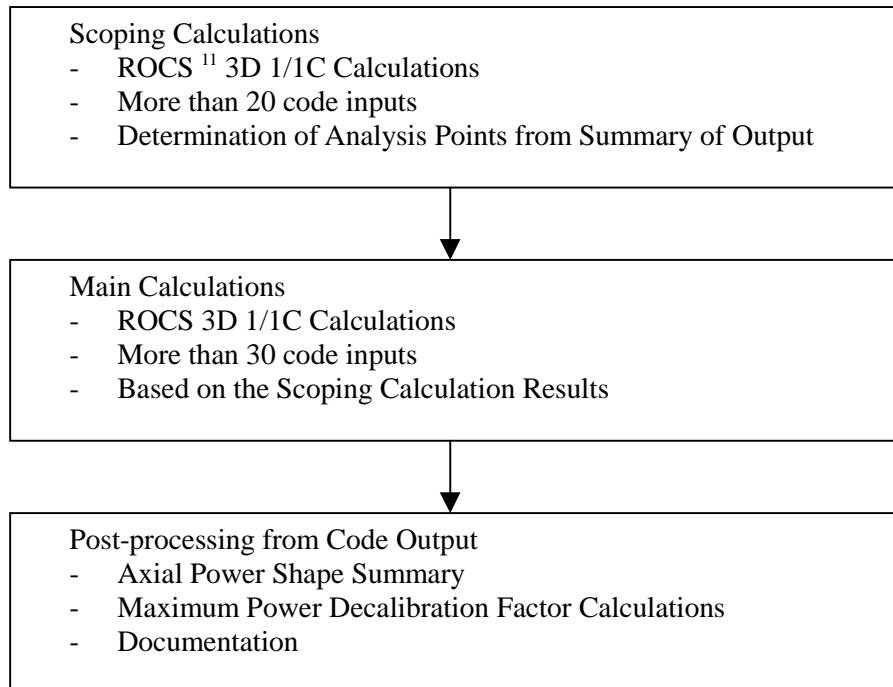


Figure 4. Design Procedure of Single CEA Withdrawal Accident

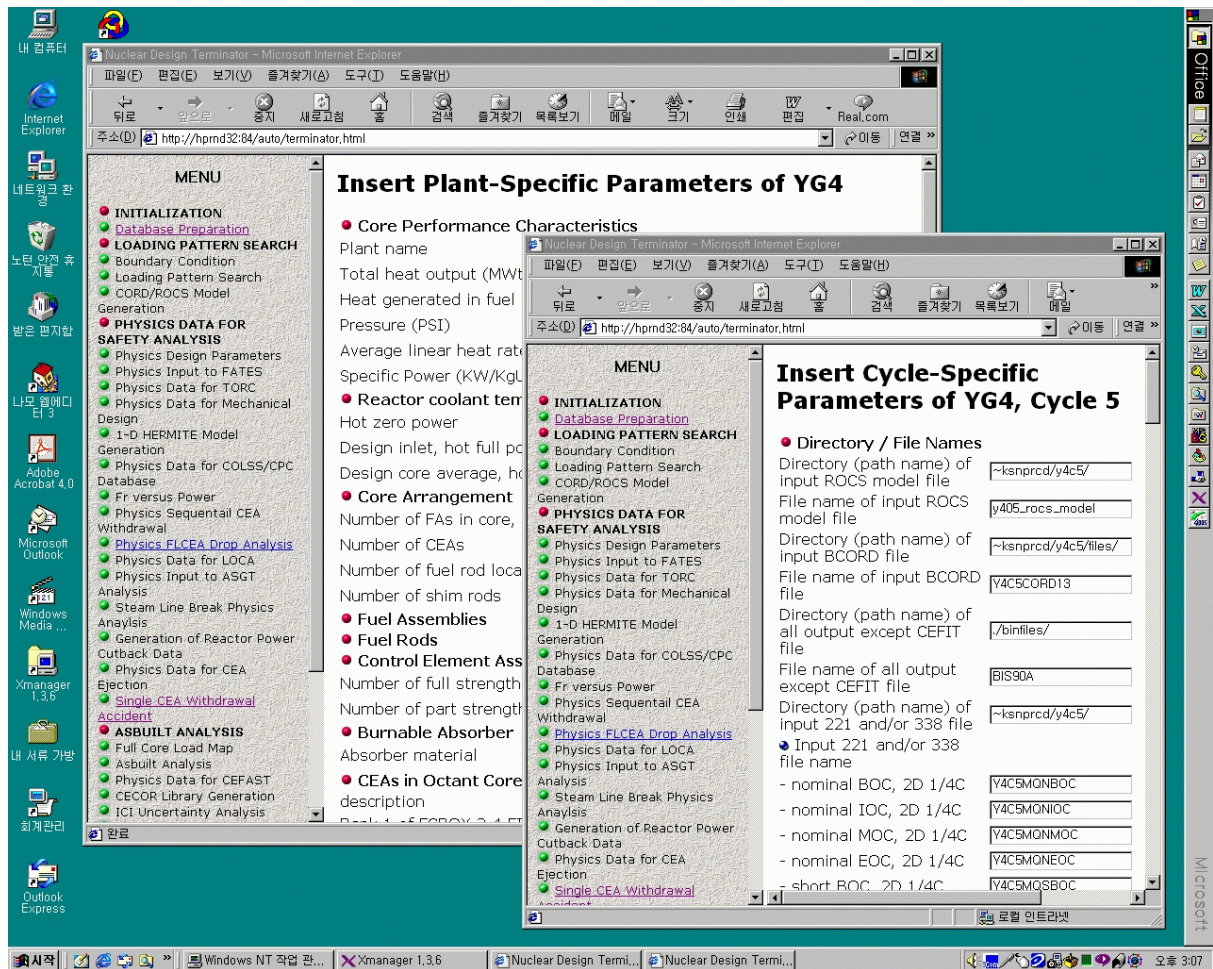


Figure 5. Data Base Preparation

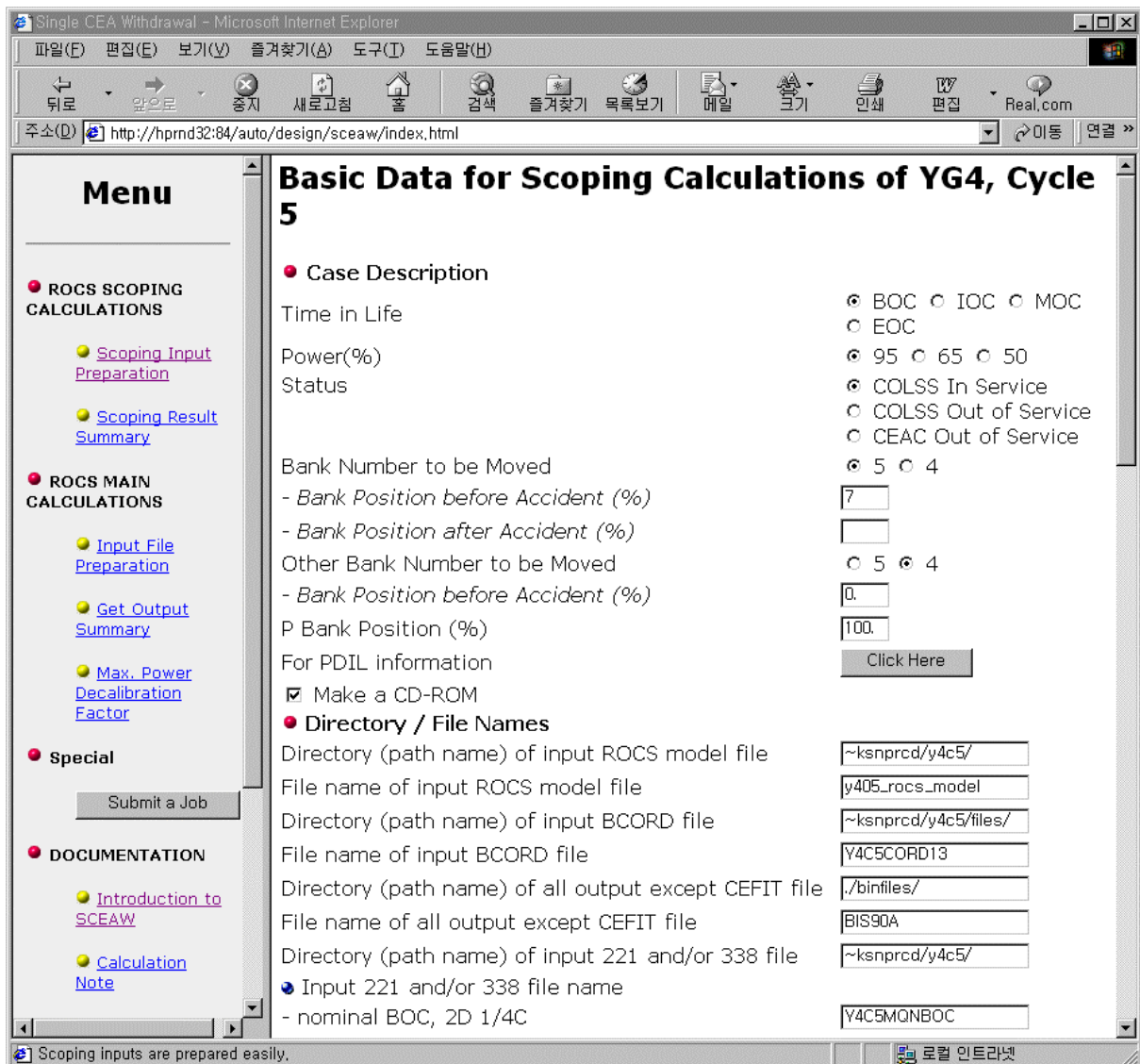


Figure 6. Scoping Input Preparation

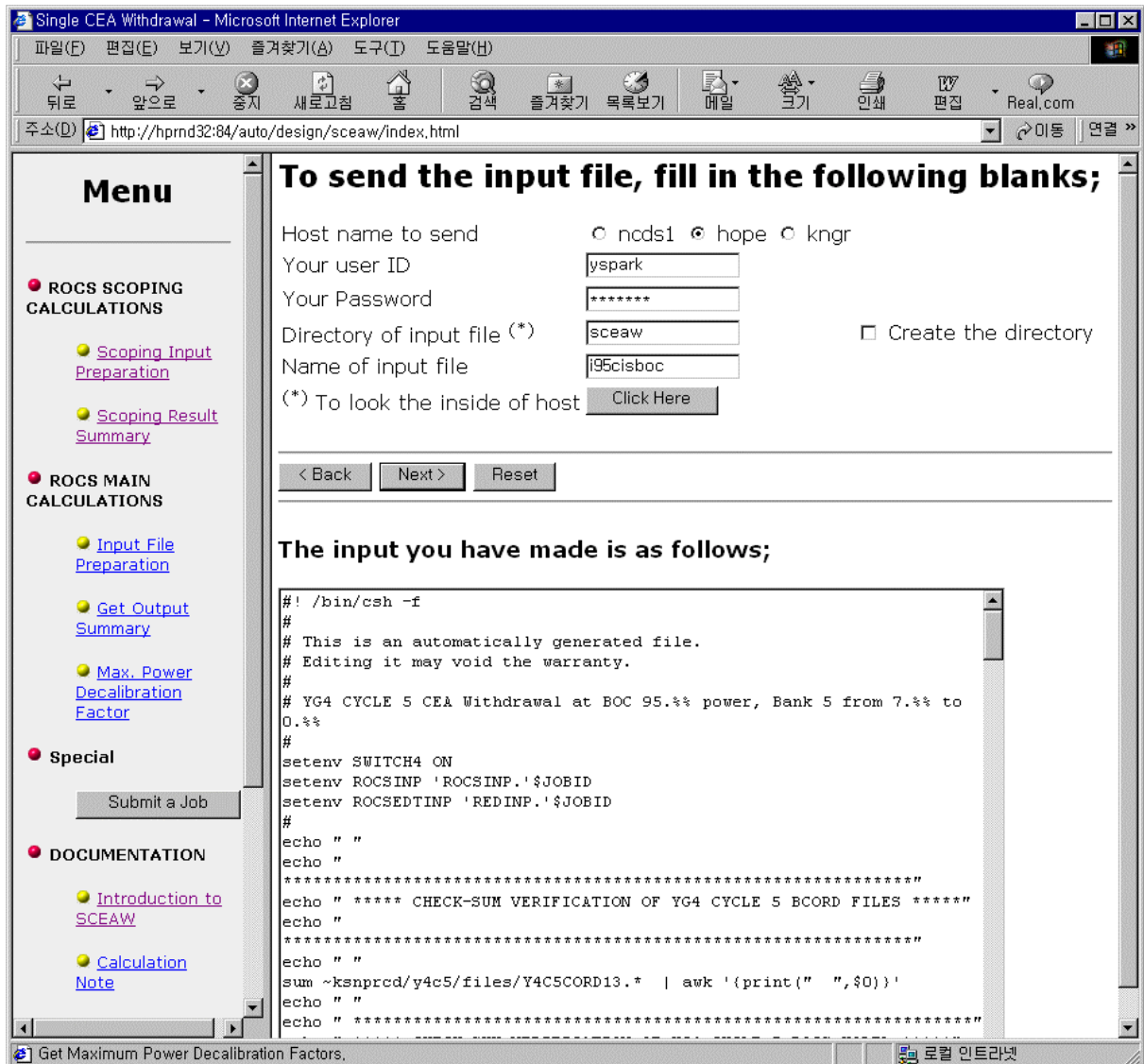


Figure 7. End of Input Preparation

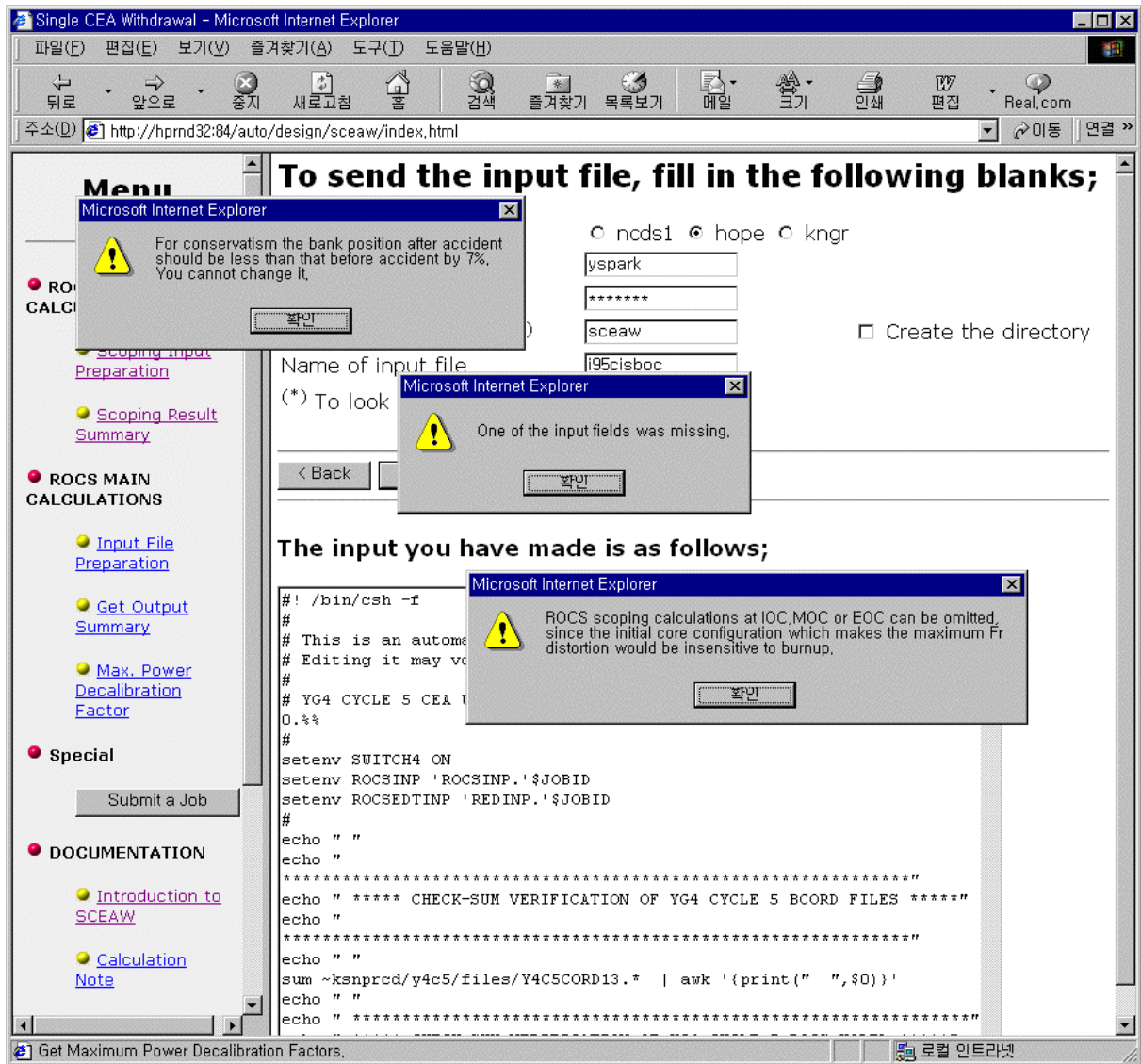


Figure 8. Example of Pop-Up Messages

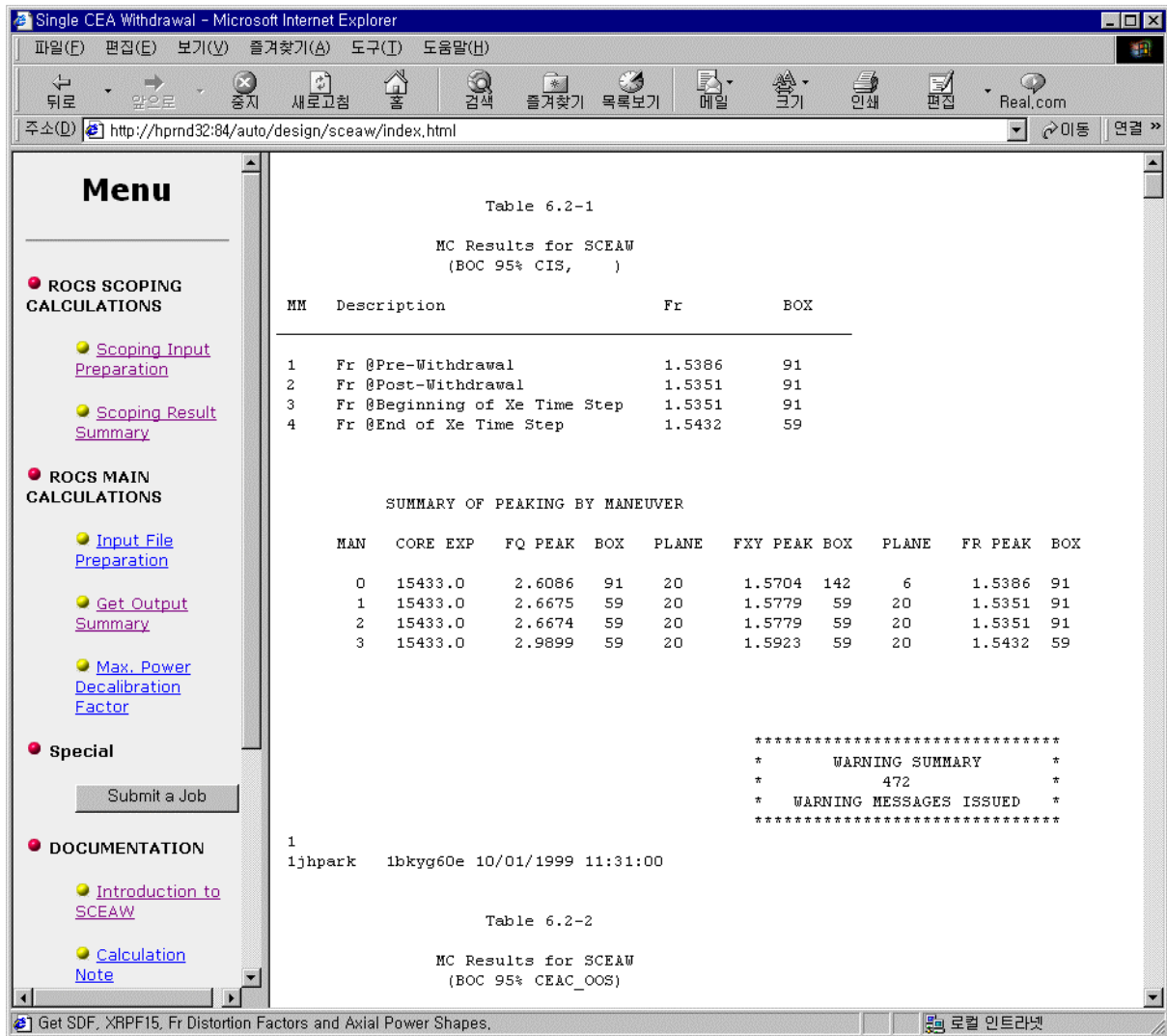


Figure 9. End of Core Calculations

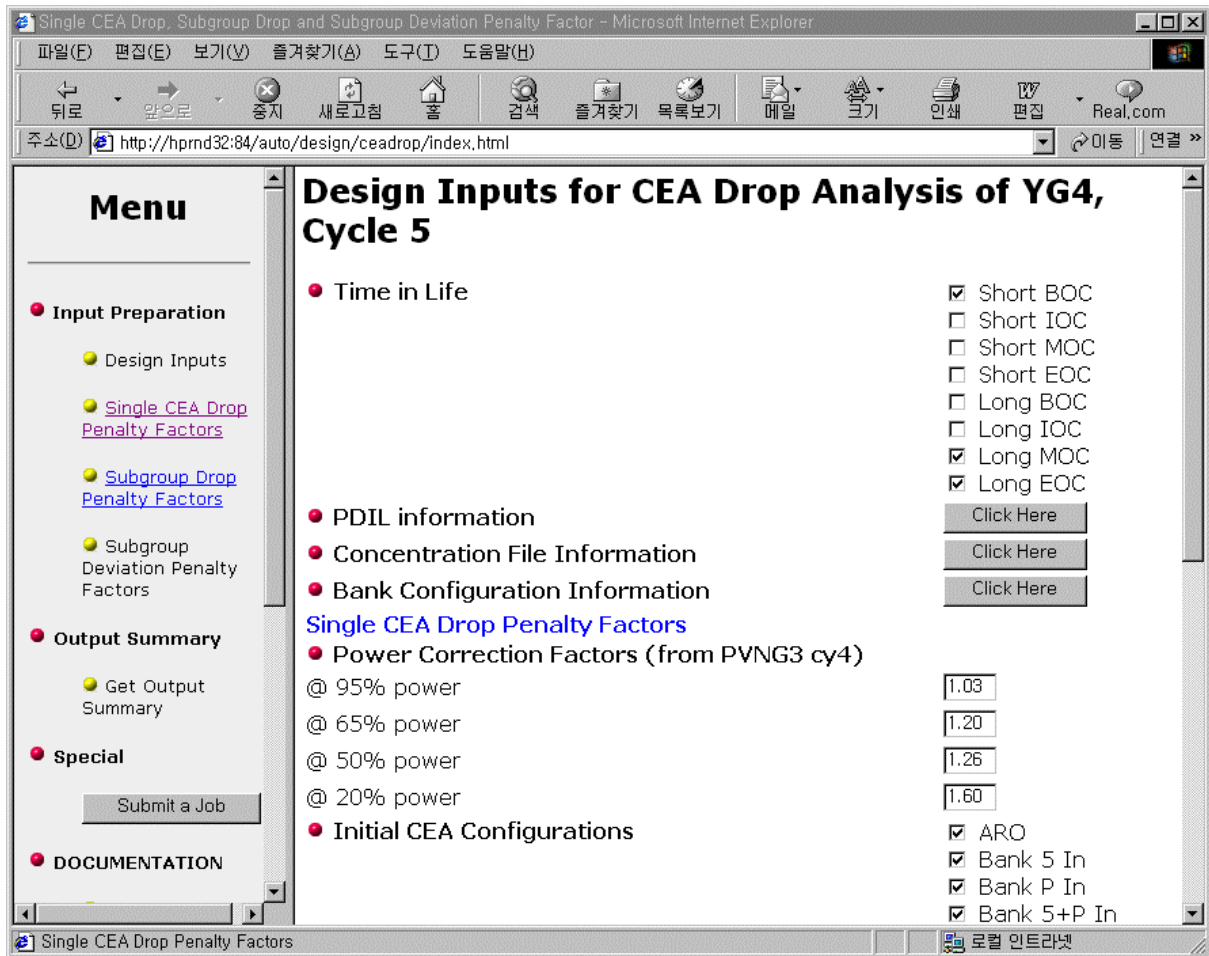


Figure 10. Design Input to CEA Drop Analysis