A preliminary uncertainty analysis of phenomenological inputs employed in MAAP code using the SAUNA system

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1. Introduction

Uncertainty analysis is an essential element of safety analysis of nuclear power plants, and especially on the increase as an essential methodology of safety assessment by computer codes. Recently, these efforts have been stepped up to apply the uncertainty methodology in severe accident analysis and PSA Level 2. From this point of view, a statistical sampling-based MAAP-specific platform for a severe accident uncertainty analysis, SAUNA, is being developed in KAERI. Its main purpose is to execute many simulations that are employed for uncertainty analysis. For its efficient implementation, the SAUNA system is composed of three related modules: Firstly, a module for preparing a statistical sampling matrix, secondly, a module for the dynamic linking between code and samples for code simulation, and thirdly, a post-processing module for further analysis of the code simulation results. The main objective of this paper is to introduce the main functions of the SAUNA system and its example of implementation.

2. Methods and Results

Uncertainty analysis can analyze the influences of various input variables or the influences of the reliability for the output variables from the analyzed results(Fig.1).

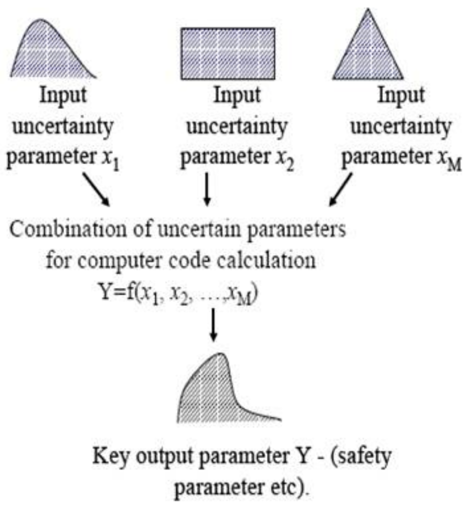

Fig. 1. Sampling-based uncertainty analysis procedure

These analyses are treated importantly in the PSA Level 2 and severe accident analysis field which includes uncertainty[1]. Even though the severe accident analysis code is to be quantumized applying more advanced model or numerical approaches, the uncertainty always exists due to the inherent diversity complexity. In time-consuming computer code execution, the most effective method for analyzing uncertainty is to apply the computer based platform which can execute enormous simulation automatically as a part of the code execution.

The purpose of the uncertainty analysis is to assess the impact of a set of varying inputs on the resultant output or a confidence level of the output. Although the severe accident code is being qualified by employing advanced models and numerical approaches, a greater or lesser uncertainty is unavoidable due to an essential complexity of the relevant phenomenon[2]. The effective approach of uncertainty analysis through a time-consuming integral computer code is to employ a computer-based platform which automatically implements lots of simulations as a part of an integral code[3]. The SAUNA (Severe Accident UNcertainty Analysis) system can be a tool of such platforms, which employs a sampling-based approach to quantify systematically the overall uncertainty employed in the MAAP code by means of statistical analysis. The sampling-based approach for the uncertainty analysis is simple to implement and the analysis results are robust as long as an appropriate number of statistical samples are employed for the uncertainty analysis. For example, the state of knowledge about all uncertain parameters is described by ranges and subjective probability distribution. Then, the random variance of each uncertain parameter is determined by either a crude or stratified Monte Carlo sampling method according to the combined probability distribution of the uncertain parameters. Finally, the MAAP code calculations are performed with a given number of samples, one by one[4]. The aforementioned dynamic linking between code and samples makes it possible to analyze in a quick and efficient way.

An overall process for uncertainty analysis using the SAUNA system is shown in Fig.2. As shown in this figure, the first step for uncertainty analysis is to generate a set of statistical values for the user-specified inputs, using the aforementioned module for statistical sampling. The next step is to dynamically link between the user-specified number of parameter values and the corresponding uncertainty parameters employed in the MAAP input deck. The final step is to generate the corresponding number of MAAP output values for further analysis (such as a statistical analysis). As a result, the i-*th* MAAP code output is automatically allocated into the corresponding sub-directory. All the processes are implemented under an MS visual studio environment.

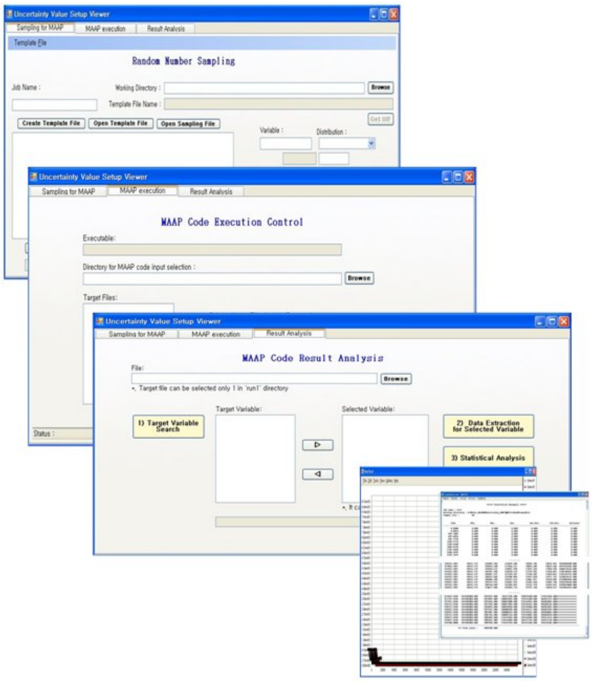

Fig 2. Implementation for Uncertainty analysis

For the purpose, key elements of the SAUNA system are as follows:

Sampling of uncertainty inputs

- Edit interface file: specification of working directory and sampling algorithm, uncertainty variables, and number of code calculations, etc.
- Produce sampling number

Execution control of MAAP code with each sample

- Create MAAP input matched with each sample
- MAAP code run and automatic allocation of analysis results in the relevant sub-directory
- Results analysis: all the MAAP plot variables

Result analysis

- Statistical analysis of the user-specified target variables
- Graphical processing of the user-specified target variables

All the functions are processed in a single window platform which is composed of three implementation steps. Whenever each step is implemented, the corresponding log files are generated to check the corresponding result including error messages. As an example case, Fig.3 shows each of the results after the aforementioned step-by-step implementation. After sampling and linking with the MAAP code, the i-*th* MAAP input for calculation is automatically assigned to the corresponding sub-directory. After the execution of the MAAP code, each calculation result is also stored in the corresponding sub-directory. All the results are analyzed through statistical result and graphical result.

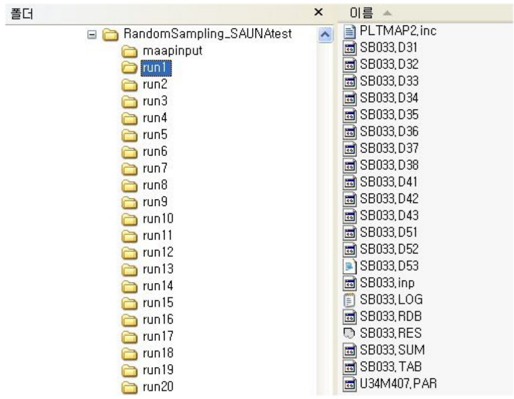

Fig.3. The result set of MAAP code execution

3. Conclusions

For an uncertainty analysis in the severe accident code MAAP, the SAUNA system is being developed, which is composed of three closely-related modules. The preliminary implementation of the system to MAAP has shown that the present system could perform lots of code simulations to obtain a statistical confidence on the code outputs in a fast and efficient way, without a tedious time-consuming process. Further improvement is expected through its application to more practical situations in various ways (e.g., employing more probability types, various accident sequences, and more versatile modeling and parameter inputs, etc.).

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