Development of Source Term Uncertainty Analysis Supporting Program, MERTAG

Jihyun Kim, Hoyoung Shin, and Moosung Jae [*]
Department of Nuclear Engineering, Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul, 04763, Republic of Korea
[*]*Corresponding author: jae@hanyang.ac.kr*

1. Introduction

Since severe accidents generally have extreme conditions, such as high-temperature, high-pressure, and high-radiation, there are difficulties in experimenting and verifying the phenomena of the accidents. Accordingly, there are considerable uncertainties in simulating severe accidents with computer codes, and various studies have been conducted to treat these uncertainties.

The regulatory authorities in Korea and the United States, MELCOR code is used to analyze severe accidents and their source terms characteristics. Although the uncertainty analysis system using MELCOR has been sufficiently established through previous studies, the following problems remain in handling the uncertainty analysis results.

A PTF file (MELCOR Plot File), which has the result data of a simulation, is created when MELCOR simulates a severe accident scenario. In spite of the differences on the scope of accident analysis and the characteristics of accident, a PTF file size can be usually measured in hundreds of MB (Megabyte), dozens of GB (Gigabyte). For performing uncertainty analysis, at least hundreds of samples as well as hundreds of PTF files are required. In addition, reading a variety of PTF files, extracting data in files, and statistical data processing will be needed for handling the uncertainty analysis result. However, the number of PTF files and the size of PTF files are too considerable to carry out analysis.

The process, which consists of three steps, is very demanding and time-consuming task. In this regard, we developed the MELCOR Result to Table and Graph (MERTAG) program.

2. MERTAG Program

2.1 The MELCOR Plot File

Loading PTF files is the first step of executing MERTAG. The PTF file, an output produced by MELCOR, is not a text file but a binary file [4]. Owing to the type of PTF file, a special translator or interpreter is required to read PTF files. Table I shows the PTF file format. The PTF file consists of a contiguous set of blocks and each block is composed of three Sections: Header, Specials, Time Records [4].

2.2 Program Logic

Among these sections, reading the Time Records Section, which contains considerable binary time-series data, is necessary for analyzing and plotting results. With the special reader, MERTAG reads numerous and massive PTF files and prints data collectively. Despite of identical time step, each PTF file's calculation time sets have slightly differences.

Table I: A typical structure of a MELCOR Plot file

	Block	Section	Subsection
M E L C O R P L O T F I L E	Block 1	Header	Title
			Key
		Specials	Special Data
			Special Data
		Time Records	Time Record
			Time Record
	Block 2	Header	Title
			Key
		Time Records	Time Record
			Time Record
	⋮	⋮	⋮
	Block n	Header	Title
			Key
		Time Records	Time Record
			Time Record

To solve this problem, MERTAG generates identical time step and interpolates time-series data. With interpolated data, two parameters, which are the arithmetic mean and the standard deviation, can be calculated. The logarithmic mean (mu) and logarithmic standard deviation (sigma) are calculated from the arithmetic mean and the standard deviation. Using these parameters, MERTAG estimates 5th percentile, median, 95th percentile values. The program logic of MERTAG can be expressed as Figure 1.
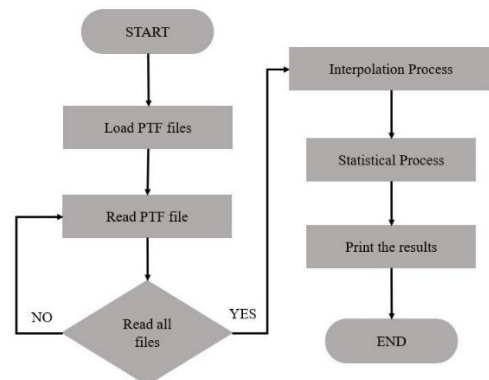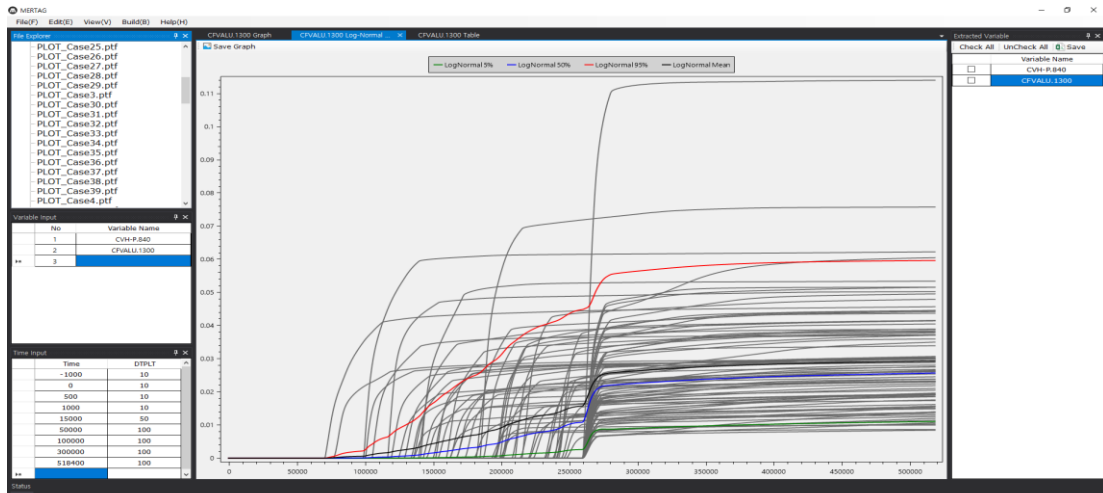

Fig. 1. A simplified flowchart of MERTAG.

Fig. 2. A sample screenshot of MERTAG.

Printing a table and plotting a graph are the end of MERTAG, as shown in Figure 2. By using a file save function, the result formats are saved as CSV (Comma-separated Values) file and PNG (Portable Graphics Format) file, respectively.

2.3 Benchmarking

Since a PTF file, which is a binary file, is only used in MELCOR, to verify MERTAG reads PTF files properly is crucial. To conduct the verification, IPLOT and PTFREAD were used. IPLOT and PTFREAD, which read PTF files, were developed by Korea Atomic Energy Research Institute (KAERI) and U.S. Sandi National Laboratories (SNL), respectively. MERTAG, IPLOT, and PTFREAD read a test-case PTF file and extracted the release mass of Cs class variable. Table II shows the results of reading PTF file using three tools.

Table II: The comparison of MERTAG, IPLOT, and PTFREAD when reading a PTF file.

	Time (seconds)	Mass of Cs class (kg)
MERTAG	229803.28125	2.997020E-04
	229903.28125	3.003863E-04
	230003.28125	3.010826E-04
	230103.28125	3.017536E-04
	230203.28125	3.023946E-04
IPLOT	229803	2.997E-04
	229903	3.004E-04
	230003	3.011E-04
	230103	3.018E-04
	230203	3.024E-04
PTFREAD	229803.3	2.99702E-04
	229903.3	3.003863E-04
	230003.3	3.010826E-04
	230103.3	3.017536E-04
	230203.3	3.023946E-04

3. Example of Source Term Uncertainty Analysis

MERTAG is verified by the uncertainty analysis in source term with a sample scenario. For the verification, WH600 (Westinghouse two-loop plant) is selected as a reference plant. As a test-case scenario, a Station Blackout (SBO) is selected as an initiating event. In the scenario, the turbine-driven auxiliary feedwater pumps are only available and can operate 2 hours. To verify MERTAG, only uncertainty analysis in MELCOR input variables was considered.

Referring to the previous studies' results, 24 input were selected as the target inputs for MELCOR uncertainty analysis. The number of samples was determined to be 100 [1]. The input samples were generated by MELCOR Uncertainty Software, which uses Latin Hypercube Sampling (LHS) techniques. The samples were simulated using MELCOR version 2.2. Table III and Figure 3 show the results of plotting and statistical processing of PTF files using MERTAG.

Table III: The result of uncertainty analysis in mass of Cs class released to the environment.

Time (seconds)	5th percentile	Median	Mean	95th percentile
518400	4.47	6.52	6.69	9.51

4. Conclusions

Since severe accidents have large uncertainties, various studies on severe accident uncertainty analysis have been performed using MELCOR. The uncertainty analysis system using MELCOR has been sufficiently organized. Nevertheless, the problems on handling the uncertainty analysis results have remained. Numerous PTF files, which have MELCOR results, can be created because of many samples for conducting uncertainty analysis. Also, the PTF file, which is a binary file, have considerable time-series data. Reading numerous PTF files, extracting data, and statistical data processing take an enormous amount of man-power and a lot of time.
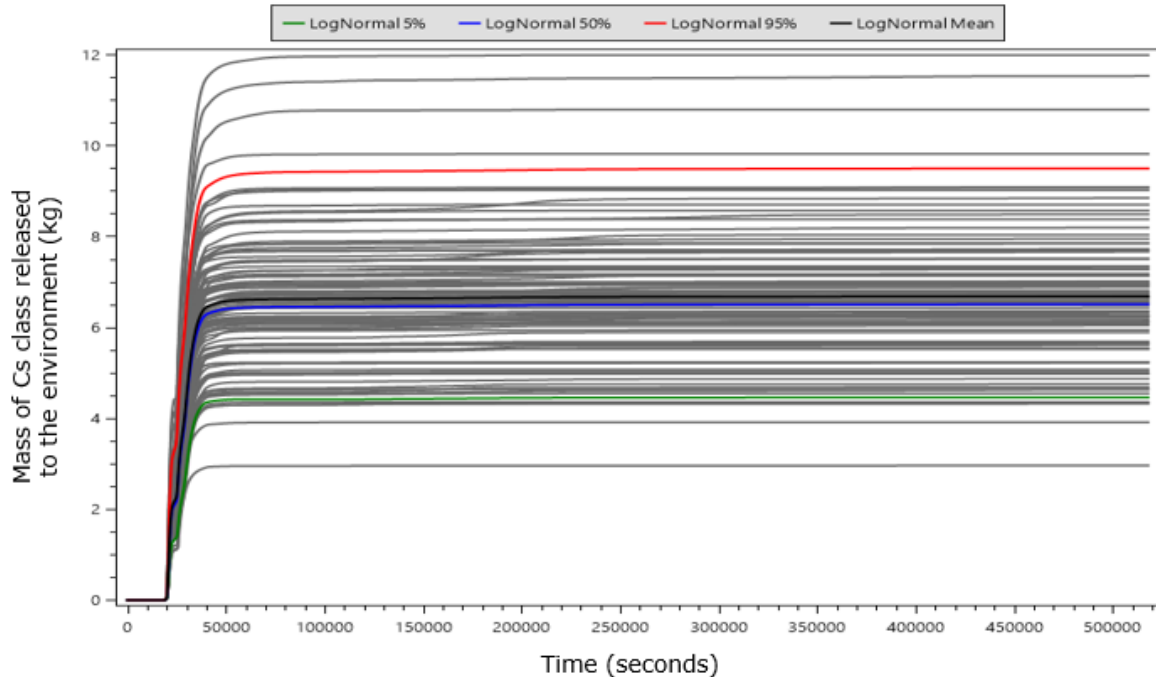
Fig. 3. An example of source terms uncertainty analysis results.

MERTAG, which was developed program, fully systematizes this process, and runs it automatically. MERTAG can not only save many required resources efficiently but also estimate release characteristics more easily. As future work, we will conduct that uncertainty analysis is possible for other factors such as hydrogen generation, containment pressure.

Acknowledgement

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