Preliminary Study of Correlation between Variables in Sensitivity Analysis of PWR Safety Analysis

Min-Gil Kim, Jeong Ik Lee*
Department of Nuclear and Quantum engineering, Korea Advanced Institute of Science and Technology (KAIST)
291 Daehak-ro, (373-1, Guseong-dong), Yuseong-gu, Daejeon 34141, Republic of Korea
**Corresponding author: jeongiklee@kaist.ac.kr*

1. Introduction

From IAEA safety standards, deterministic safety analyses for anticipated operation occurrences (AOOs), design basis accidents (DBAs) and beyond DBAs are necessary for confirming the adequacy of safety provisions. For the licensing process, the best-estimate codes are used for the best-estimate approach. Sensitivity and uncertainty analysis should be performed for the licensing of the nuclear power plants. For the sensitivity and uncertainty analysis, several hundreds of safety analysis calculations by varying the number of parameters are performed. PAPIRUS, a framework for sensitivity analysis, uncertainty propagation and estimation of parameter distribution is developed by KAERI [1]. Another study, which is an uncertainty quantification method by comparing monte-carlo methods and Wilk's formula is done in Korea as well [2]. Following these studies, the authors are going to compare the results of the safety analysis with changes in multiple variables and the sensitivity obtained by performing a safety analysis by perturbing variables one by one.

2. Methods and Results

In this study, a sensitivity analysis is performed for LBLOCA case first. As a preliminary study, the authors show the results of safety analyses by changing two variables.

2.1 Reference NPP and Reference System Code

APR1400, which is the Korea's major nuclear power plant model is set as the reference nuclear power plant. Fig. 1. shows the nodalization for the LBLOCA analysis of APR1400. For the safety analysis, MARS-KS V1.5 is used as the reference system thermal-hydraulic analysis code to generate the LBLOCA analysis results [3]. Fig. 2. shows the LBLOCA analysis results by MARS-KS code with the APR1400 LBLOCA nodalization, which is shown in Fig. 1.

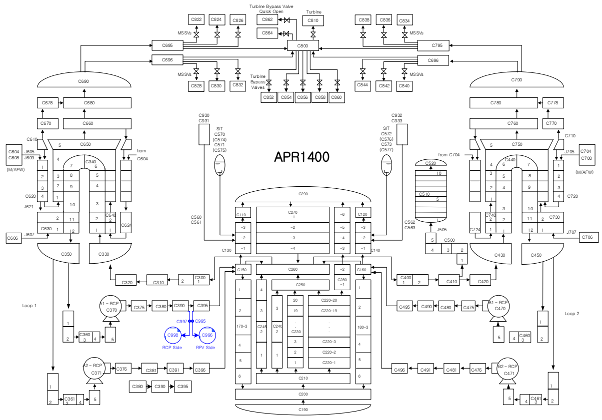

Fig. 1. APR1400 LBLOCA Nodalization

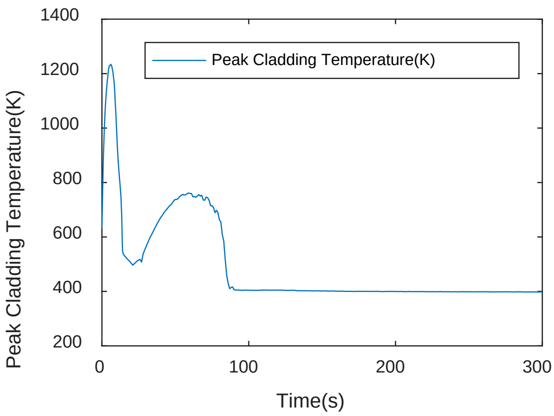

Fig. 2. PCT profile for selected LBLOCA case for APR1400.

2.2 Methods

The authors developed an in-house code using MATLAB program to generate the input file of MARS-KS and run the bin file of MARS-KS. Using the developed in-house code, LBLOCA analyses are performed by changing the variables shown in Table I. For this study, the authors selected variables from the reference [4] that can be handled in the input without modifying the MARS-KS.

Table I: Variables used in thesStudy

Name	Component
Fuel condutivity	Fuel
Core power	Fuel
Decay heat	Fuel

Pump K-factor	Loop
Pump head multiplier	Loop
Pump torque multiplier	Loop
Pressurizer pressure	Pressurizer
SIT pressure	SIT
SIT water volume	SIT
SIT water temperature	SIT
IRWST watet temperature	SIT

For each variable, the LBLOCA analyses are performed with a variation of within +-5%. Furthermore, calculations which have variations in two variables are carried out.

2.3 Results

As a sample result, PCT calculation results which can show the correlation between two variables are shown in Fig. 3. and Fig. 4. Fig. 3. compares PCT calculation results with the increased core power and PCT calculation results with the increased core power with the increased or decreased SIT water temperature.

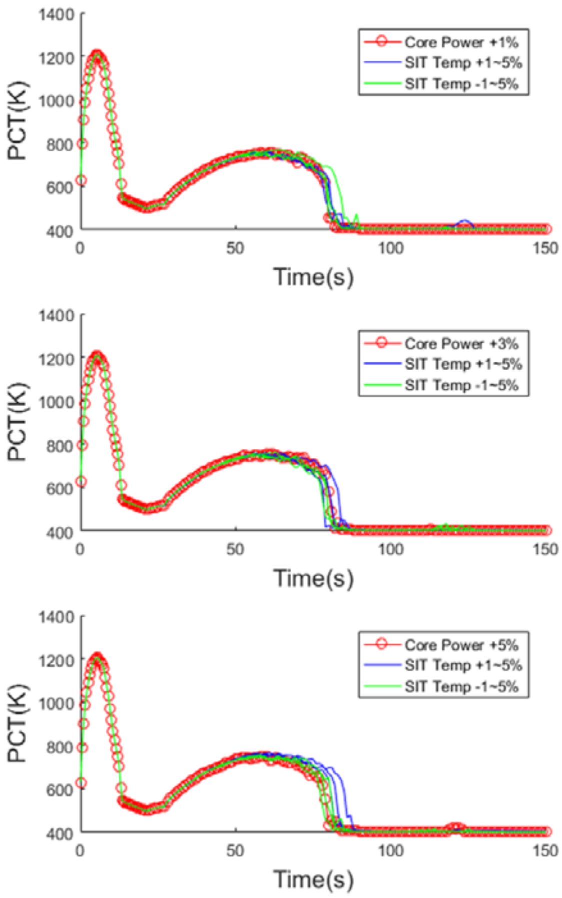

Fig. 3. PCT profile for selected LBLOCA case for APR1400(Core power and SIT water temperature variation).

In Fig. 3., the blowdown peak region is less affected by the change in the variables, core power and SIT water temperature. When the core power increase is 1%, the reflood peak region of the PCT calculation is also less affected by the SIT water temperature. However, when the core power increased by 3% and 5%, the reflood peak region appears to be affected by the change in SIT water temperature. This tendency is observed when the core power is decreased. In Fig. 4., the reflood peak region appears to be affected by the SIT water temperature change, especially when the SIT water temperature increases, as the core power decreases.

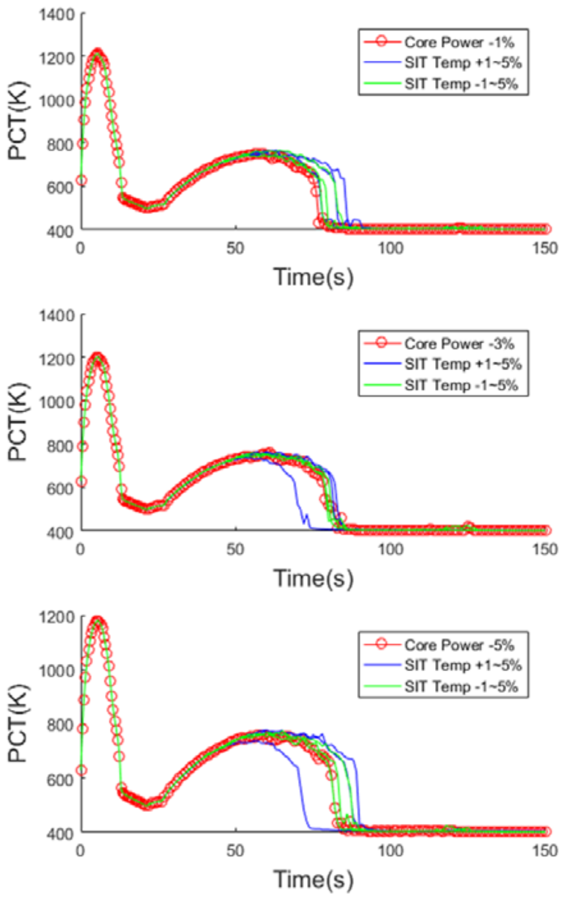

Fig. 4. PCT profile for selected LBLOCA case for APR1400(Core power and SIT water temperature variation).

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3. Summary

The authors performed a number of safety analysis calculations for LBLOCA to observe the correlation between variables in safety analysis of nuclear power plants. The authors showed the results of PCT calculations with changes in core power and SIT water temperature together, and observed some correlation between the two variables. For the further works, analyses will be performed for various variables and quantitative analyses will be performed for the calculation results.

REFERENCES

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